

Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline



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Disclaimer:

This guideline was developed by the National Pressure Ulcer Advisory Panel, the European Pressure Ulcer Advisory Panel and the Pan Pacific Pressure Injury Alliance. It presents a comprehensive review and appraisal of the best available evidence at the time of literature search related to the assessment, diagnosis, prevention and treatment of pressure ulcers. The recommendations in this guideline are a general guide to appropriate clinical practice, to be implemented by qualified health professionals subject to their clinical judgment of each individual case and in consideration of the patient consumer's personal preferences and available resources. The guideline should be implemented in a culturally aware and respectful manner in accordance with the principles of protection, participation and partnership.

Printed copies of the English version of this guideline can be ordered, and PDFs downloaded, from the following websites:

NPUAP

EPUAP

Wounds Australia (previously Australian Wound Management Association) website:

Hong Kong Enterostomal Therapists Association Society

New Zealand Wound Care Society (NZWCS)

Wound Healing Society Singapore

International Pressure Ulcer Guideline

npuap.org

epuap.org

awma.com.au

www.etnurse.com.hk

nzwcs.org.nz

woundhealingsociety.org.sg

internationalguideline.com

INTRODUCTION

Foreword

This *Clinical Practice Guideline* presents recommendations and summarizes the supporting evidence for pressure ulcer prevention and treatment. The first edition was developed as a four year collaboration between the National Pressure Ulcer Advisory Panel (NPUAP) and the European Pressure Ulcer Advisory Panel (EPUAP). In this second edition of the guideline, the Pan Pacific Pressure Injury Alliance (PPPIA) has joined the NPUAP and EPUAP. This edition of the guideline has been developed over a two year period to provide an updated review of the research literature, extend the scope of the guideline and produce recommendations that reflect the most recent evidence. It provides a detailed analysis and discussion of available research, critical evaluation of the assumptions and knowledge in the field, recommendations for clinical practice, a description of the methodology used to develop the guideline and acknowledgements of the 112 experts formally involved in the development process.

A *Quick Reference Guideline* version that contains excerpts from the *Clinical Practice Guideline* is also available. The quick reference guideline is intended for busy health professionals who require a quick reference in caring for individuals in the clinical setting. Users should not rely on excerpts from the *Quick Reference Guideline* alone.

The goal of this international collaboration was to develop evidence-based recommendations for the prevention and treatment of pressure ulcers that could be used by health professionals throughout the world. An explicit scientific methodology was used to identify and critically appraise all available research. In the absence of definitive evidence, expert opinion (often supported by indirect evidence and other guidelines) was used to make recommendations. Drafts of the recommendations and supporting evidence were made available to 986 invited stakeholders (individuals and organizations) around the world. The final guideline is based on available research and the accumulated wisdom of the NPUAP, EPUAP, PPPIA and international stakeholders. In this edition of the guideline, a consensus voting process (GRADE) was used to assign a strength to each recommendation. The strength of recommendation identifies the importance of the recommendation statement based on potential to improve patient outcomes. It provides an indication to the health professional of the confidence one can have that the recommendation will do more good than harm, and can be used to assist in prioritizing pressure ulcer related interventions.

Printed copies of the English version of the *Clinical Practice Guideline* are available through links provided on the following websites:

NPUAP website:	www.npuap.org
EPUAP website:	www.epuap.org
Wounds Australia (previously Australian Wound Management Association) website:	www.woundsaustralia.com.au
Hong Kong Enterostomal Therapist Society website:	www.etnurse.com.hk
New Zealand Wound Care Society (NZWCS) website:	www.nzwcs.org.nz
Wound Healing Society Singapore website:	www.woundhealingsociety.org.sg
International Pressure Ulcer Guideline website:	www.internationalguideline.com

Suggested Citation

The NPUAP, EPUAP and PPPIA welcome the use and adaptation of this guideline at an international, national and local level. We request citation as the source, using the following format:

National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline. Emily Haesler (Ed.). Cambridge Media: Osborne Park, Western Australia; 2014.

Limitations and Appropriate Use of This Guideline

- Guidelines are systematically developed statements to assist health professional and patient consumer decisions about appropriate health care for specific clinical conditions. The recommendations may not be appropriate for use in all circumstances.
- The decision to adopt any particular recommendation must be made by the health professional with consideration to available resources and circumstances of the individual patient. Nothing contained in this guideline is to be considered medical advice for specific cases.
- Because of the rigorous methodology used to develop this guideline, the Guideline Development Group members believe that the research supporting these recommendations is reliable and accurate. Every effort has been made to critically appraise the research contained within this document. However, we do not guarantee the reliability and accuracy of individual studies referenced in this document.
- This guideline is intended for education and information purposes only.
- This guideline contains information that was accurate at the time of publication. Research and technology change rapidly and the recommendations contained in this guideline may be inconsistent with future advances. The health professional is responsible for maintaining a working knowledge of research and technology advances that may affect his or her clinical decision making.
- Generic names of products have been used. Nothing in this guideline is intended as endorsement of a specific product.
- Nothing in this guideline is intended as advice regarding coding standards or reimbursement regulations.
- The guideline does not seek to provide full safety and usage information for products and devices; however commonly available safety and usage tips have been included. Adverse events reported in the included research have been reported in the evidence summaries and caution statements. All products should be used according to manufacturer's directions.

Abstract

This guideline is the result of a collaborative effort among the National Pressure Ulcer Advisory Panel (NPUAP), European Pressure Ulcer Advisory Panel (EPUAP) and Pan Pacific Pressure Injury Alliance (PPPIA). A comprehensive literature review was conducted on pressure ulcer prevention and treatment. A rigorous scientific methodology was used to appraise available research and make evidence-based recommendations for the prevention and treatment of pressure ulcers. Draft guidelines were made available to 986 invited stakeholder individuals and organizations/societies and stakeholder feedback was considered by the guideline developers. In the final development process, the guideline development team used a consensus voting process (GRADE) to assign strengths of recommendation. Strength of recommendations indicate the extent to which one can be confident that adherence to a recommendation will do more good than harm, and are intended to assist the health professional to prioritize interventions. The guideline includes 575 explicit recommendations and/or research summaries for the following pressure ulcer topics: etiology; prevalence and incidence; risk assessment; skin and tissue assessment; preventive skin care; prophylactic dressings; microclimate control; fabrics and textiles; nutrition; repositioning and early mobilization; support surfaces; medical device related pressure ulcers; pressure ulcer classification; wound assessment; monitoring of healing; pain assessment and treatment; cleansing; debridement; wound dressings (including growth factors and biological wound dressings); assessment and treatment of infection and biofilms; biophysical agents (e.g. electrical stimulation, negative pressure wound therapy, electromagnetic field treatment); and surgery. Additional sections address the specific needs of special populations including bariatric individuals, critically ill individuals, older adults, pediatric individuals, individuals in palliative care and individuals in the operating room setting. The guideline includes sections to assist in implementing the guideline within organizations, including quality improvement strategies, quality indicators, health professional education and recommendations to assist patient consumers. The guideline also includes the NPUAP/EPUAP International Pressure Ulcer Classification system, complete with full Category/Stage descriptions and illustrative photography.






Strengths of Evidence and Strengths of Recommendations

Full explanation of the methodology is available in *Appendix 1: Guideline Methodology*. Individual studies were assigned a '**level of evidence**' based on study design and quality. The body of evidence supporting each recommendation was given a '**strength of evidence**'. A consensus voting process (GRADE) involving all the experts formally engaged in the guideline development was used to assign a '**strength of recommendation**' that indicates the confidence the health professional can have that the recommended practice will improve patient outcomes (i.e., do more good than harm). The overall aim of the '**strength of recommendation**' is to help health professionals to prioritize interventions.

Strengths of Evidence

- | | |
|----------|---|
| A | The recommendation is supported by direct scientific evidence from properly designed and implemented controlled trials on pressure ulcers in humans (or humans at risk for pressure ulcers), providing statistical results that consistently support the recommendation (Level 1 studies required). |
| B | The recommendation is supported by direct scientific evidence from properly designed and implemented clinical series on pressure ulcers in humans (or humans at risk for pressure ulcers) providing statistical results that consistently support the recommendation. (Level 2, 3, 4, 5 studies) |
| C | The recommendation is supported by indirect evidence (e.g., studies in healthy humans, humans with other types of chronic wounds, animal models) and/or expert opinion |

Strengths of Recommendation

- | | |
|---|--|
|  | Strong positive recommendation: definitely do it |
|  | Weak positive recommendation: probably do it |
|  | No specific recommendation |
|  | Weak negative recommendation: probably don't do it |
|  | Strong negative recommendation: definitely don't do it |

Guideline Website

<http://www.internationalguideline.com>

The guideline website will remain accessible during the interim period until the next guideline revision. The *Quick Reference Guideline*, sponsor acknowledgement, and supportive documents to the guideline are available from the website.

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Janet Cuddigan, PhD, RN, CWCN, FAAN, Interim Methodologist (literature update, review and analysis during the interim between formal guideline development activities [2009 to 2012])

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McGoogan Library, University of Nebraska Medical Center, Omaha, NE, USA (consultation on database searches, journal access and interlibrary loan services)

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Translation

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Stakeholders

Special thanks to the many stakeholders who reviewed the guideline processes and drafts. All stakeholder comments were reviewed by the Guideline Development Group and revisions were made based on the comments received. We appreciate the investment of health professionals, researchers, educators and manufacturers from all over the world who took time to share their expertise and thoughtful critique.

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EXECUTIVE SUMMARY

Significance

Pressure ulcers are a frequently occurring health problem throughout the world. They are painful, costly, and an often preventable complication for which many individuals are at risk.

Around the world, pressure ulcer prevalence in health care settings ranges from 0%¹ to 72.5%,² with large variations observed between different countries and clinical settings (e.g., acute care, aged care and community care). Average prevalence in acute care settings is cited as approximately 10%.³ In general acute care, there appears to be a gradual and ongoing decline in pressure ulcer prevalence over the past decade,⁴ driven in part by growing international health policy focus on prevention of pressure ulcers. However, there are no clear trends in other clinical settings. Prevalence and incidence rates are generally higher in unique populations who are at elevated risk, such as those receiving palliative care,³ those with spinal cord injuries,⁵ neonates and infants,^{6,7} and individuals in critical care.^{8,9}

Pressure ulcers represent a major burden of sickness and reduced quality of life for patient consumers and their care givers.¹⁰⁻¹⁶ Increased morbidity and mortality associated with pressure ulcer development in hospitalized patients is documented in multiple studies.^{10, 11, 17} Hospital lengths of stay, readmission rates, and hospital charges are greater in individuals who develop a pressure ulcer than in those remaining ulcer free.¹⁸⁻²⁰ The development of a single pressure ulcer in hospitals in the United States (US) can increase the patient's length of stay five-fold.¹⁷ Additionally, the personal burden associated with a chronic wound, including pain and discomfort;^{21, 22} stress, anxiety and depression,¹⁰⁻¹² lowered autonomy and security; and impaired social functioning¹¹ is immeasurable.

Pressure ulcers increase hospital costs significantly. In the US, pressure ulcer care is estimated to approach \$11 billion (USD) annually,²³⁻²⁵ with a cost of between \$500 (USD) and \$70,000 (USD) per individual pressure ulcer.^{23, 25, 26} European cost models highlight that the cost of illness associated with pressure ulcers consumes up to 1.4% of health care expenditure in the Netherlands^{27, 28} or between \$362 million and \$2.8 billion annually.²⁸ In the United Kingdom (UK) pressure ulcers cost up to 4% of the annual health care budget²⁹ (or £750 million annually²⁶) with expenses estimated at £30,000 per individual pressure ulcer.²⁶ When community health care costs are added to hospital costs, pressure ulcers consume up to £2.1 billion of the National Health Service (NHS) budget.³⁰ In Australia, associated opportunity cost related to increased hospital length of stays arising from development of pressure ulcer is an estimated mean \$285 million (AUD).²⁶

Purpose and Scope

The goal of this guideline is to provide evidence based recommendations for the prevention and treatment of pressure ulcers that can be used by health professionals throughout the world. The purpose of the prevention recommendations is to guide evidence based care to prevent the development of pressure ulcers and the purpose of the treatment focused recommendations is to provide evidence-based guidance on the most effective strategies to promote pressure ulcer healing.

The guideline is intended for the use of all health professionals, regardless of clinical discipline, who are involved in the care of individuals who are at risk of developing pressure ulcers, or those with an existing pressure ulcer. The guideline is intended to apply to all clinical settings, including hospitals, rehabilitation care, long term care, assisted living at home, and unless specifically stated, can be considered appropriate for all individuals, regardless of their diagnosis or other health care needs. The sections of the guideline for *Special Populations* add further guidance for population groups with additional needs, including those in palliative care, critical care, paediatric and operating room settings; bariatric individuals; individuals with spinal cord injury; and older adults. Additionally, the guideline may be used as a resource for individuals who are at risk of, or have an existing pressure ulcer, to guide awareness of the range of preventive and treatment

strategies that are available. Classification of mucosal membrane pressure ulcers is beyond the scope of this guideline.

Guideline Development

The US National Pressure Ulcer Advisory Panel (NPUAP), European Pressure Ulcer Advisory Panel (EPUAP) and Pan Pacific Pressure Injury Alliance (PPPIA) collaborated to update the guidelines on the prevention and treatment of pressure ulcers and amalgamate the previous edition of two guidelines (prevention and treatment) into one comprehensive clinical practice guideline.

The guideline was produced by an interprofessional guideline development group (GDG) and numerous small working groups (SWGs), each consisting of representatives of the three development organizations. The GDG determined and monitored the guideline development process with the assistance and management of a guideline methodologist. The guideline was made available to stakeholders on a website for further input and feedback.

The first step in the guideline development process was identifying the new evidence. The GDG commissioned a comprehensive review of the literature on pressure ulcer prevention and treatment in several electronic databases using a sensitive search strategy. All retrieved references were screened by the GDG and methodologist on pre-determined inclusion criteria and preliminary data extraction tables were completed. In a second step, the retrieved evidence was evaluated, and thereafter the full texts were divided according to topic and provided to the relevant SWGs. With the assistance of the methodologist, the SWG members conducted critical appraisals of the evidence, assigned a level of evidence to each study using a classification system adapted from Sackett (1997)³¹, and refined the evidence tables.

The next stage was drafting the recommendations. Each SWG formulated conclusions about the body of available evidence and developed recommendations that emerged from the evidence. Recommendations from the 2009 guideline were reviewed and revised based on insights from new evidence and an analysis of the current cumulative body of evidence. The strength of the body of evidence was determined. This rating identifies the strength of cumulative evidence supporting a recommendation. The SWGs summarized the evidence supporting each recommendation. Recommendations and evidence summaries were reviewed by the GDG and international stakeholders with final drafts approved by the GDG.

The final stage involved determining the strength of each recommendation statement. Each individual who was involved in the guideline development process was invited to review every recommendation and participate in a web-based consensus voting process in which strength of recommendations were assigned. The recommendation strength represents the confidence a health professional can place in each recommendation, with consideration to the strength of supporting evidence; clinical risks versus benefits; cost effectiveness; and systems implications.

The full methodological process is outlined in *Appendix 1: Guideline Methodology*.

Guideline Recommendations

Recommendations are systematically developed statements to assist health professional and patient consumer decisions about appropriate health care for specific clinical conditions. The recommendations may not be appropriate for the use in all circumstances.

The recommendations in this guideline are a general guide to appropriate clinical practice, to be implemented by qualified health professionals subject to their clinical judgment of each individual case and in consideration of the patient consumer's personal preferences and available resources. The guideline should be implemented in a culturally aware and respectful manner in accordance with the principles of protection, participation and partnership.

The guidance provided in the guideline should not be considered medical advice for specific cases. This book and any recommendations within are intended for educational and informational purposes only. Generic names of products are provided. Nothing in this guideline is intended as an endorsement of a specific product.

Background

The background section of the guideline comprises three topics: etiology, prevalence and incidence, and the International NPUAP/EPUAP Pressure Ulcer Classification System.

Etiology

The *Etiology* section is an introductory section to the guideline. The development process for this section differed from sections addressing evidence-based clinical care topics. Etiology research is focussed on basic science and is not appropriate for critical appraisal using the same strategies used for clinical studies or assignment of levels of evidence. In this update, new research in the etiology field was identified and reviewed for relevance by the SWG. Papers considered to advance and build on the state of the art or knowledge that was presented in the 2009 guideline publication were included in this guideline update. The section provides a brief overview of four concepts in the etiology of pressure ulcers: mechanical load magnitude and time, tissue reactions to different types of mechanical loading, mechanisms that lead to tissue damage and factors that influence susceptibility to pressure ulcers.

Prevalence and Incidence

The *Prevalence and Incidence* section has been added to this guideline update to provide background information on the significance of pressure ulcers in different clinical settings. Due to the vast volume of publications in this field, the section was developed to provide an overview of prevalence and incidence patterns, rather than a comprehensive record of all available data. A recent extensive monograph on prevalence and incidence³² was used for background data, and the SWG reviewed and reported additional studies published after the search date for the monograph. The section, which is intended as a background overview, provides commentary on current trends in pressure ulcer prevalence and incidence in a range of settings. Expert opinion recommendations for the conduct of prevalence and incidence studies are presented.

International NPUAP/EPUAP Pressure Ulcer Classification System

In the 2009 guideline, the NPUAP and EPUAP presented a common international definition and classification system for pressure ulcers. The international classification system represents international consensus on the classification of pressure ulcers that was developed as a replacement to the very similar previous scales used in the US and Europe. The International NPUAP/EPUAP Pressure Ulcer Classification System was adopted in the Pan Pacific region in 2012.³³

The international classification system includes four Categories/Stages of pressure ulcers (I to IV) that describe and classify localized injury to the skin and/or underlying tissue, as well as two additional categories (unstageable and suspected deep tissue injury) that describe pressure injury for which the full extent of damage to the tissue and skin remains unknown. The classification system remains unchanged in this 2014 guideline update.

Prevention of Pressure Ulcers

The prevention specific section of the guideline comprises four topics: pressure ulcer risk, assessment of skin and tissue, preventive skin care and emerging preventive therapies.

Risk Factors and Risk Assessment

Risk assessment is an essential component of clinical practice that aims to identify individuals who are susceptible in order that appropriate interventions to prevent pressure ulcer occurrence can be planned and implemented. Using a structured approach to risk assessment to identify factors that impact on an individual's risk is of primary importance. This includes the use of a structured approach to risk assessment (e.g., a risk assessment tool) in combination with a comprehensive skin assessment, consideration of additional risk factors and the health professional's clinical judgment. This section presents a multivariable model of epidemiological evidence on factors that are associated with increased risk for pressure ulcers. The section identifies activity/mobility limitations and skin status as the most important factors that contribute to pressure ulcer risk. Tissue perfusion, nutritional status and skin moisture are factors that also impact on risk. Additional factors that potentially impact on pressure ulcer risk are also discussed.

Skin and Tissue Assessment

Skin assessment is crucial in pressure ulcer prevention because skin status is identified as a significant risk factor for pressure ulcer development. The skin can serve as an indicator of early pressure damage. Skin and tissue assessment underpins the selection and evaluation of appropriate preventive interventions. This section of the guideline comprises recommendations on skin assessment, including the identification and differentiation of erythema, components of a comprehensive skin and tissue assessment and considerations when assessing individuals with darkly pigmented skin.

Preventive Skin Care

Promoting skin integrity and protecting the skin from damage is an important component of every pressure ulcer prevention plan. This section of the guideline comprises recommendations on how to protect the skin from pressure ulcer development through such measures as protecting erythematous skin from further exposure to pressure, avoidance of massage and vigorous rubbing, promotion of skin hydration and protecting the skin from excessive extrinsic moisture.

Emerging Therapies for Prevention of Pressure Ulcers

This section of the guideline introduces topics of emerging research, including microclimate control, prophylactic dressings, low friction textiles and fabrics and electrical stimulation of the muscles in individuals with spinal cord injury (SCI). There is growing appreciation of the potential these areas of research have in addressing the risk of pressure ulcers in different patient populations, and the recommendations in this section provide guidance on the implementation of these emerging preventive strategies.

Interventions for Prevention and Treatment of Pressure Ulcers

Five sections of the guideline present interventions that are used for both prevention and treatment of pressure ulcers. Nutrition, repositioning and early mobilization, addressing heel pressure, support surfaces and medical device management are all areas of care that are implemented both as a preventive measure, and to promote healing of existing pressure ulcers.

Nutrition for Pressure Ulcer Prevention and Treatment

Multivariable analyses of epidemiological data indicate that a poor nutritional status, indicated by low body weight or poor dietary intake among other signs, is a factor that impacts upon pressure ulcer risk. All individuals at risk of pressure ulcers should have their nutritional status screened. A comprehensive assessment should be conducted where risk of malnutrition is identified, and in individuals with existing pressure ulcers. This section of the guideline includes comprehensive recommendations on strategies that can promote nutritional status, thereby reducing pressure ulcer risk and/or promoting wound healing. The importance of ensuring adequate caloric, protein, vitamin, mineral and fluid intake is highlighted.

Repositioning and Early Mobilization

Repositioning involves a change of position in the lying or seated individual, with the purpose of relieving or redistributing pressure and enhancing comfort. Repositioning and its frequency should be considered in all at risk individuals and must take into consideration the condition of the individual and the support surface in use. Repositioning should maintain the individual's comfort, dignity and functional ability. The importance of correct manual handling technique, pressure relief schedules for seated individuals and promotion of early mobilization is discussed. This section of the guideline also addresses pressure relief in individuals with existing pressure ulcers, and the importance of avoiding positioning individuals on areas of existing non-blanchable erythema.

Repositioning to Prevent and Treat Heel Pressure Ulcers

Heel pressure ulcers are a challenge to prevent and manage. The small surface area of the heel is covered by a small volume of subcutaneous tissue that can be exposed to high mechanical load in individuals on bedrest. The recommendations in this section of the guideline address the importance of regular inspection and correct positioning in order to relieve heel pressure while avoiding potential complications such as Achilles tendon damage, foot drop and deep vein thrombosis (DVT).

Support Surfaces

Support surfaces are specialized devices for pressure redistribution and management of tissue load and microclimate. The recommendations in this section address mattress and bed use, seats and cushions, and other forms of support surface (e.g. overlays). The importance of using a high specification pressure redistribution support surface in all individuals at risk of pressure ulcers or with existing pressure ulcers is highlighted. The evidence on various high specification support surfaces is presented; however, it is evident that there is insufficient research to identify any specific type of high specification support surface as superior. The use of pressure redistribution cushions for both prevention and treatment of pressure ulcers is discussed, along with guidance on product selection and use. Safety and maintenance issues are addressed.

Medical Device Related Pressure Ulcers

Individuals with a medical device in situ are at a high risk of pressure ulcers related to the device. These pressure ulcers often conform to the pattern or shape of the device and develop due to prolonged, unrelieved pressure on the skin, often contributed to by associated moisture around the device, impaired sensation or perfusion and/or local edema, as well as systemic factors. The recommendations in this section address assessment of skin that is placed at risk due to a medical device, strategies to redistribute pressure associated with a device, and skin protection. The importance of selection of the most appropriate medical device (e.g., in terms of design, size and individual fit) is highlighted.

Treatment of Pressure Ulcers

Classification of Pressure Ulcers

Pressure ulcer treatment begins with an accurate diagnosis and classification of pressure ulcers. The International NPUAP/EPUAP Pressure Ulcer Classification System is recommended. This section of the guideline includes considerations regarding differential diagnosis of wounds and classification of pressure ulcers with special considerations in individuals with darkly pigmented skin. The section addresses appropriate use of the classification system, and the importance of verifying clinical agreement amongst health professionals responsible for classifying pressure ulcers.

Assessment of Pressure Ulcers and Monitoring of Healing

An initial holistic assessment should be conducted on the individual and the pressure ulcer in order to develop an appropriate individualized treatment plan. Reassess the individual and the treatment plan if the ulcer fails

to show signs of healing within two weeks. The pressure ulcer should be assessed at least weekly using the strategies outlined in this section of the guideline.

Pain Assessment and Treatment

Pressure ulcers are painful. Pain assessment and management is a significant component of providing quality care to an individual with a pressure ulcer. Pain is often under-recognized and under-treated. This section includes comprehensive recommendations for identifying and assessing pain and its characteristics for individuals with pressure ulcers, including children and individuals with cognitive impairment. Recommendations on strategies to prevent or reduce pain and treatment of procedural pain and chronic pain are presented.

Wound Bed Preparation: Cleansing, Debridement and Dressings

Overarching principles of wound bed preparation are presented. Recommendations and research evidence are provided for the critical approaches necessary to prepare the wound bed for healing: cleansing, debridement and selection of the most appropriate dressings. For most pressure ulcers, cleansing with potable water or normal saline and use of a clean dressing technique is appropriate. Removal of devitalized tissues through debridement is believed to play a key role in wound bed preparation for chronic wounds. Recommendations on appropriate use and safety aspects of debridement are presented. The emerging role of debridement in the treatment of biofilm is also discussed. In the *Wound Dressings* section of the guideline, the vast volume of evidence on a large range of dressing types is presented, along with guidance on selecting the most appropriate dressing based on the unique needs of the individual pressure ulcer and patient. A more limited role of growth factors and biological wound dressings is discussed in the *Growth Factors for the Treatment of Pressure Ulcers* and *Biological Dressings for the Treatment of Pressure Ulcers* sections of the guideline.

Assessment and Treatment of Infection and Biofilms

Pressure ulcers do not heal in the presence of infection or biofilm. Prevention, early diagnosis and effective treatment are critical components of pressure ulcer healing; however, in the era of growing antibiotic resistance it is pertinent to ensure that topical and systemic antibiotics agents are not used unnecessarily in wound care. This section of the guideline includes recommendations on early identification of critical colonization and local infection using subtle clinical indicators, such as new or increasing ulcer pain, pocketing, friable granulation tissue and increased wound exudate. Quantitative tissue culture remains the gold standard for diagnosing infection, and treatment with a range of properly selected and topical antiseptics of appropriate strength (e.g., polyhexamethylene biguanide [PHMB], silver and cadexomer iodine) is increasingly recommended. The section also includes the newest evidence on identification and treatment of biofilm in chronic wounds using debridement and topical antimicrobial agents.

Biophysical Agents in Pressure Ulcer Treatment

Different forms of energy (e.g., mechanical, electrical, magnetic, acoustic and light) have been used in the management of pressure ulcers. There is sufficient direct evidence from studies of individuals with pressure ulcers to recommend both electrical stimulation and negative pressure wound therapy as biophysical agents that can facilitate wound healing. Expert opinion and indirect evidence provide support for the use of pulsed electromagnetic field treatment, pulsed radio frequency energy, ultraviolet light, low frequency ultrasound, high-frequency ultrasound and pulsed lavage with suction in specific clinical circumstances. For other biophysical agents, there is insufficient evidence for their effectiveness in contributing to healing in pressure ulcers. This section of the guideline presents the available evidence and recommendations for safe use of biophysical agents.

Surgery for Pressure Ulcers

For some pressure ulcers, conventional wound healing techniques are insufficient and surgery is considered. In some cases urgent surgical intervention may be required when the individual has clinical signs of severe worsening infection or sepsis. This section of the guideline presents the evidence on surgical interventions and recommendations on the pre-operative, intra-operative and post-operative management of an individual who undergoes surgical repair of a pressure ulcer.

Special Populations

Specific patient populations and/or those in specific clinical settings are at greater risk of pressure ulcers and particular attention should be paid to preventive planning. These sections of the guideline outline the specific needs and considerations for the following populations:

- *Bariatric Individuals*
- *Critically Ill Individuals*
- *Older Adults*
- *Individual in the Operating Room*
- *Individuals with Spinal Cord Injury*
- *Individuals in Palliative Care*
- *Pediatric Individuals*

Particular features of severe obesity include maceration, inflammation and tissue/skin necrosis, particularly in large skin folds. Coupled with decreased ability to transfer and mobilize, bariatric individuals have specific pressure ulcer risk. Older adults are particularly vulnerable to pressure ulcers due to the more likely presence of significant risk factors including decreased mobility, skin integrity alteration and declining nutritional, continence and sensory status. Immobility associated with anesthesia increases the pressure ulcer risk of individuals in the operating room environment. Palliative care is a high risk setting for pressure ulcer development, as individuals at the end of life experience organ system failure, including skin failure. Often under-recognized, pediatric health care settings report higher pressure ulcer prevalence than many adult health care settings, and risk for infants and neonates is increased due to chronic illness and/or the presence of medical devices. Individuals with spinal cord injury experience an increased risk of pressure ulcers at every stage of their care, including a lifelong risk that needs consideration every day. The special populations sections of this guideline provide specific recommendations for these populations that, for the most part, should be considered in conjunction with the recommendations throughout the full clinical guideline.

Implementing the Guideline

The newly introduced implementation section of the guideline addresses systems and strategy at an organization and professional level that are required for effective implementation of the clinical recommendations in this guideline. This includes sections addressing implementation strategy, health professional education, recommendations specifically for patient consumers and their caregivers, and quality indicators for monitoring guideline implementation.

Facilitators, Barriers and Implementation Strategy

This section of the guideline provides a review of quality improvement research published from 1st January, 2008 to 31st December, 2012. Quality of evidence in this field is extremely varied, and the SWG narrowed the research by seeking evidence of sustained effectiveness of reproducible interventions. Assessment of potential barriers and facilitators to guideline implementation, including education level of staff and appropriate equipment is essential prior to the introduction of a pressure ulcer prevention protocol. The evidence supporting practical strategies including nurse-led quality improvement, introduction of wound care specialists and awareness campaigns is presented.

Health Professional Education

Negative attitudes and lack of knowledge are common barriers to using guidelines in clinical practice. This section of the guideline provides a review of research on the effectiveness of strategies related to health professional education published from 1st January, 2008 to 31st December, 2012. Recommendations on the format, content and evaluation of education programs are made.

Patient Consumers and Their Caregivers

The patient consumer and his or her informal caregivers play an important role in pressure ulcer prevention. Knowledge of pressure ulcers and their prevention is important, and requires a special emphasis in those at high risk. This section of the guideline discusses responsibilities of the patient consumer to attain information and work with health professionals in order to prevent and treat pressure ulcers. The section also provides guidance on the selection and maintenance of equipment.

Quality Indicators for This Guideline

Monitoring of practice is an important component of continuous quality improvement. The quality indicators identified in this section of the guideline are intended for auditing the implementation of this clinical guideline in practice. The identified quality indicators are those that are considered important indicators of successful implementation of the guideline and delivery of quality pressure ulcer prevention and treatment. The indicators could be used by organizations who introduce the evidence-based practices recommended within this guideline, and may be measured in conjunction with other quality indicators (e.g. those associated with facility accreditation) to determine progress in provision of quality care and identify areas for improvement.

Further Research Needs

The paucity of high quality research on prevention and treatment of pressure ulcers was highlighted in the guideline update. Many of the recommendations in the guideline are based on expert opinion and indirect evidence (e.g. conducted in different types of wounds or different populations). This section of the guideline is important to researchers, as the GDG has identified areas for which there is a strong need of good quality evidence attained from well-designed studies.

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BACKGROUND

THE ETIOLOGY OF PRESSURE ULCERS

Introduction

A pressure ulcer is a localized injury to the skin and/or underlying tissue, usually over a bony prominence, resulting from sustained pressure (including pressure associated with shear).

A number of contributing or confounding factors are also associated with pressure ulcers; the primary of which is impaired mobility.

Pressure Ulcer or Pressure Injury?

Since the first description of the injury referred to above, there has been debate regarding terminology. The oldest term is **decubitus**, originally described as **gangraena per decubitum** by Wohlleben (1777), which means 'dead tissue due to lying down', thus referring to wounds developed by patients while in bed. Etiological research started with the work of Groth (1942)¹ and a number of seminal studies and papers by Kosiak (1959)² and Reichel (1958)³. Groth (1942)¹ used the term **decubitus**, Reichel (1958)³ used **decubitus ulcers** and Kosiak (1959)² used several terms including **ischemic ulcers**. None of these terms are accurately descriptive and the term used by Kosiak (1959)² implies an overly limited etiological pathway.

The term **bedsore** arose following publication of *Bedsore Biomechanics*⁴ an edited book that followed the first international conference on pressure ulcer etiology held in 1975 in Glasgow. This term maintains the association with the bed, despite knowledge at the time that pressure ulcers could be acquired whenever soft tissues are in contact with supporting surfaces, and of the major role played by shear forces and shear deformation. The addition of **sore** implies a raw or painful place on the body.

In the 1980s the term **pressure sore** became more popular, thus no longer relating the injury to the bed. Since the early 1990s the term **pressure ulcer**, referring to an open ulcer at the skin surface that is difficult to heal or fails to heal, has been in common usage. However, this term fails to capture both deep tissue injury, an internal wound under intact skin (see *Classification* section of this guideline) and Category/Stage I pressure ulcers in which skin remains intact.

All the above terms are still in use by clinicians and/or patients. In Europe and North America the term **pressure ulcer** is widely used. South-East Asia, Australia and New Zealand have recently adopted the term **pressure injury**. Although none of these terms accurately describes the full etiology behind the injury, they all refer to the same phenomenon described in the introduction to this guideline section, and terminology is still the subject of ongoing discussion. In this version of the guideline the term pressure ulcer is used.

Mechanical Load: Magnitude and Time

This section defines a number of commonly used mechanical terms.

Mechanical load comprises all types of force that are applied to an individual's soft tissue as a result of contact between the skin and a solid surface (including air-filled or water-filled support surfaces, medical devices and other body surfaces). It includes forces carried by the bony structures and transmitted through the soft tissue to the supporting surface. Mechanical loads are often characterized as being a **normal force** (a force perpendicular to the skin surface) or a **shear force** (a force parallel to the skin surface). In most practical situations, the interacting force is a combination of a normal and a shear force.

Pressure is defined as normal force per unit surface area.

When two surfaces are in contact with each other, they can either be **fixed** (no sliding occurs between the surfaces) or they can slide over each other (in technical literature, referred to as **slip**). The occurrence of fixation or slip depends on surface properties and mechanical loading conditions (a combination of normal and shear forces).

In the technical literature, the term **friction** is used to describe all phenomena that relate to interface properties and sliding of surfaces with respect to each other. In literature related to pressure ulcers, including this guideline, friction is used to define the contact force parallel to the skin surface in case of slip (in technical literature this is called dynamic friction).

Continuous rubbing or sliding of a surface (e.g., a textile) along the skin can result in redness, inflammation or a wound referred to as a **friction blister**. These blisters are not considered to be pressure ulcers; however, they are covered by this clinical guideline because it is not always evident whether the injury to the skin resulted from frictional sliding or from pressure and shear.

When the body is in contact with a supporting surface, such as a wheelchair cushion or mattress, both normal forces and shear forces are generated between the body and the support. As a result, the loaded soft tissues, including skin and deeper tissues (e.g., adipose tissue, connective tissues, and muscle) will deform, resulting in **strain** (a measure of the relative deformation) and **stress** (force transferred per unit area) within the tissues. Excessive internal strains and stresses will hinder transport processes within the tissues (e.g., by reducing blood perfusion and affecting transport in interstitial spaces or transport through cell membranes).

The ways in which tissue is affected by the mechanical load is a complex process that depends on morphology (the size and shape of the different tissue layers) and the mechanical properties of the tissues involved (e.g., stiffness, strength and diffusion properties), as well as the magnitude and distribution of the mechanical force that is applied to the tissue at the point of contact with the supporting surface.

Morphology, mechanical properties and tissue tolerance can all change over time as a result of aging, lifestyle, chronic injury, or disease. In general, external mechanical loading will lead to a highly irregular internal tissue response (i.e., different responses at different locations). This can also be referred to as a **heterogeneous** or **nonhomogeneous** response.

Normal forces will be highly non-uniform across the supported areas in the presence of clinical conditions (e.g., a human body supported by a mattress or cushion), and some shear force always exists. Accordingly, considerable deformations and strains may occur within the skin and deeper tissues. While an individual is sitting in a chair it is common that internal strain levels in the muscle can reach values of 50% and above.⁵⁻⁷

Techniques available for assessment of internal deformation are magnetic resonance imaging (MRI), elastography, and ultrasound. These imaging modalities can be used in combination with subject-specific theoretical finite element models (a method of solving mechanical problems by means of a computer) to estimate stress and strain throughout the tissue and predict the risk of damage.

Pressure ulcers develop as a result of the internal response to external mechanical load. Understanding the etiology of pressure ulcers relies on an awareness of the internal response to mechanical load and not just what is apparent on the outside of the body or on the skin surface.

How Tissues Respond to Different Types of Mechanical Loading

The primary cause of pressure ulcers is a sustained mechanical load that is applied to soft biological tissues, generally near a bony prominence. Pressure gradients that induce sustained deformation of skin and subdermal tissues must be present in order for tissue damage that characterizes a pressure injury to occur.

The magnitude of the mechanical load that will lead to tissue damage depends on the duration of time for which the load is applied. Both a high load for a short period and a low load applied for a prolonged period can lead to tissue damage.^{1, 2, 8-17}

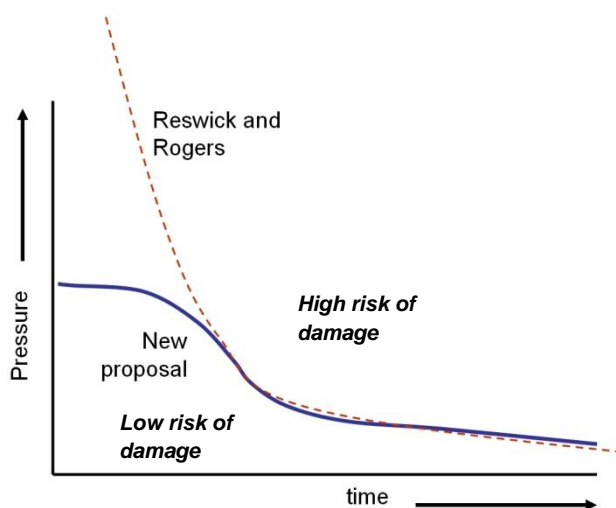
Sustained loading refers to a load that is applied for a long duration (minutes to hours or even days). In technical terms this is called a quasi-static mechanical loading. At high tissue deformations resulting from pressure and shear, damage to the cells is visible on a microscopic level within a few minutes, although it may take hours of sustained loading to become a deep tissue injury or pressure ulcer.

Impact damage, which usually occurs as a result of an accident or trauma, does not fall under the definition of pressure ulcers. Within a fraction of a second a very high mechanical load is applied to the tissue. The mass of the objects plays an important role and inertia effects leading to shock/pressure waves in the tissue may cause very high external and internal damage, all within a fraction of a second. This impact injury is not considered a pressure ulcer.

The threshold function for damage developed by Reswick et al. (1976)¹⁷ depends on pressure applied to the skin and duration of applied pressure. It was developed, based on observations of superficial damage in humans. Although Reswick et al. (1976)¹⁷ indicated that the function becomes asymptotic (meaning that it goes to infinity) for short durations of applied pressure, we understand that the absolute limit on pressure magnitude is finite as shown in *Figure 1*. The Reswick et al. (1976)¹⁷ curve should be revised to more accurately reflect the risk of tissue damage at the extremes of very short and very long loading times. High loads can almost instantaneously cause damage to tissues at a microscopic level, which can be made visible with MRI or histological techniques. Conversely, very low loads will not lead to damaged tissues even if applied for extended periods of time.

Due to variability in individual tolerance and confounding factors, it is not possible to determine quantitative values for damage thresholds as a function of time and pressure. Therefore *Figure 1* does not feature a scale along the axes.^{14, 17, 18} An example of an extrinsic confounding factor that has been shown to have a profound effect on tissue's tolerance to pressure damage is temperature.¹⁹ Another intrinsic confounding factor may be arteriole insufficiency related to diabetes.

Figure 1: Proposal for pressure/time curve according to Linder-Ganz et al. (2006)¹⁴, Gefen et al. (2008)²⁰ and Stekelenburg et al. (2007)¹⁸



Minimizing pressure at the interface between the body and the supporting surface is a valid clinical intervention for reducing the risk of developing a pressure ulcer.²¹ However, pressure alone is not a reliable measure for risk of tissue breakdown. Thus, a damage threshold based on interface pressure alone is not appropriate.^{5, 22-29}

High shear forces at the interface between body and supporting surface can exacerbate the damaging deformation caused by normal stresses alone.^{3, 11, 29, 30} Internal stresses and strains adjacent to bony

prominences are substantially higher than those near the surface, and have the potential to cause damage in deep tissues before the superficial tissue is damaged.^{5, 23, 24, 26-28, 31-33}

Friction may disturb the barrier function of the stratum corneum, and therefore represents an extra danger for infection to occur concurrently with pressure ulcers.^{11, 34}

Mechanisms That Lead to Tissue Damage

An increasing body of evidence suggests two physiologically relevant deformation thresholds exist. One is a lower threshold leading to occlusion of blood vessels resulting in ischemia-induced damage and the other is a higher threshold leading to direct deformation-induced damage.³⁵⁻⁴¹

Ischemia as a result of sustained deformation of soft tissues will lead to hypoxia, blocking of nutrient supply, and blocking of the removal of waste products. Deprivation of nutrients and change in pH due to waste products will eventually lead to tissue damage.^{10-13, 42, 43}

The duration of time for which tissue cells can endure ischemia without damage differ for muscle, fat, and skin. Muscle tissues are more susceptible to damage than skin tissues.^{10, 15, 44} Skin is much stiffer than muscle and fat and therefore deforms to a lesser degree in most clinical applications. In animal experiments, the first signs of ischemic damage are found in skeletal muscle after two to four hours of sustained deformation.^{10-13, 38, 39, 42, 43}

Muscle deformation at strains higher than 50% will almost immediately (within minutes) lead to tissue damage at a microscopic scale. At these strains there is a strong correlation between magnitude of the strain and the amount of damage to muscle. It is not clear yet what causes this direct deformation damage. Hypotheses include a direct rupture of the cytoskeleton, stretching of the plasma membrane or internal pathways that cause cell death.^{8, 9, 16, 18, 35, 45}

The balance in the interstitial space, where transport of nutrients and waste products takes place, is critical for healthy tissue homeostasis. Specifically, diffusion of nutrients, waste products, and hormones that regulate muscle metabolism may be hindered by mechanical loading.^{37, 46, 47} Recent laboratory and computational modeling work suggest that the localized sustained large deformations in weight-bearing soft tissues under bony prominences translate to large cellular deformations at the micro-scale and cause distortion of cellular organelles, for example considerable stretching of cellular plasma membranes. The prolonged exposure to large tensional plasma membrane strains may interfere with normal cellular homeostasis, primarily by affecting transport through the plasma membrane which could become more permeable when it is highly stretched. This has been visualized and quantified in cell cultures subjected to physiologically-relevant deformations for periods of two to three hours, using biomolecular fluorescent markers.^{48, 49}

Cell death and tissue necrosis cause local alterations of the mechanical properties of the injured tissues that can in turn distort the distribution of strain and stress, and are likely to exacerbate the injury.^{32, 33, 50} Reperfusion that follows a period of prolonged ischemia may increase the degree of tissue damage because it involves release of harmful oxygen free radicals.⁵¹⁻⁵⁶

An increasing body of evidence suggests that the **microclimate** between skin and the supporting surface plays a role in the development of Category/Stage I and II pressure ulcers. Microclimate refers to the humidity and temperature. With an increase in humidity and temperature, the skin becomes weaker (more vulnerable) and less stiff. Excessively dry skin becomes more brittle and liable to break. The importance of these issues and the characteristics of an optimal microclimate are still a matter of debate and ongoing research.

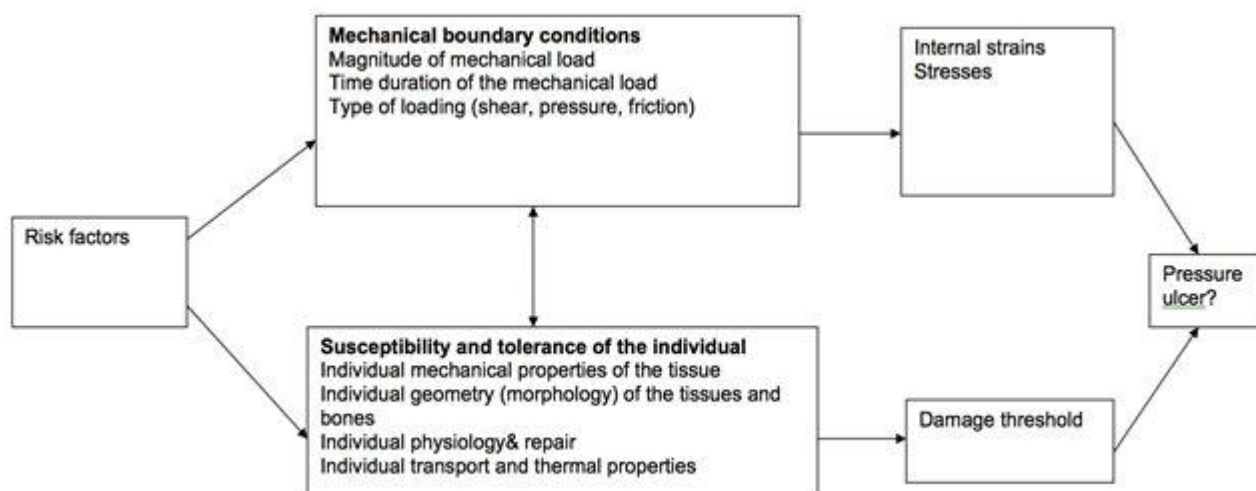
Difference in etiology of superficial pressure ulcers and pressure ulcers in deeper layers continues to be debated. Superficial ulcers may be primarily caused by high shear at the skin surface, while deeper ulcers could result from high pressure at the surface over bony prominences. Although some studies support this

proposition, the current evidence is minimal and the precise response of skin to high shear deformation is not yet fully understood.⁵⁷

Factors That Influence Susceptibility to Pressure Ulcers

A number of factors that may influence an individual's risk of developing pressure ulcers have been described in relevant research and are discussed in the *Risk Factors and Risk Assessment* section of this guideline.

Figure 2: Factors influencing the susceptibility of an individual for developing pressure ulcers (adapted from Oomens (1985)⁵⁸, used with permission in 2009 guideline, continuing work produced this modification which is published in Coleman et al. (2013)⁵⁹; reproduced with permission)



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PREVALENCE AND INCIDENCE OF PRESSURE ULCERS

Defining Prevalence and Incidence

Studies on pressure ulcer frequency have relied on describing the rates and proportions of pressure ulcer incidence and prevalence. Pressure ulcer prevalence is the proportion of individuals within a defined population (e.g., individuals within a specific geographic region, a facility or a ward) that have a pressure ulcer within a defined period of time.

Point prevalence is the number of individuals with a pressure ulcer at a specific point in time (usually on a specific day). The pressure ulcers may have developed recently, or over an extended period of time and for inpatients, they may have been present on admission to the facility.^{1,2}

Point prevalence (%)

$$\frac{\text{number patients with pressure ulcer at a specific point in time}}{\text{total number patients in the study population at a specific point in time}} \times 100$$

Pressure ulcer incidence is the proportion of pressure ulcer free individuals that develop a pressure ulcer over a specific period of time and therefore provides an indication of the rate at which new pressure ulcers occur in a specified population.

Cumulative incidence is the proportion of a specified population that develops a new pressure ulcer within a specified time period (usually weeks or months). In calculating cumulative incidence, a population free of pressure ulcers is identified and then followed for a specified time period, with periodic determinations of the presence of pressure ulcers for each individual.^{1,2}

Cumulative incidence (%)

$$\frac{\text{number patients developing pressure ulcer during a specific time period}}{\text{total number patients in the study population over a specific time period}} \times 100$$

Period prevalence is also commonly reported, often because of the time it takes to collect data for a pressure ulcer prevalence study. Period prevalence is the number of individuals who have a pressure ulcer over a specified period of time (usually days or weeks). It describes existing rather than new pressure ulcers identified during a specified time period rather than at a specific point in time, and is therefore a combination of prevalence and incidence.^{1,2}

Facility-acquired pressure ulcer rates measures the number of individuals with pressure ulcers at a specific point in time that were acquired at the facility (also referred to as nosocomial, hospital-acquired or healthcare-acquired pressure ulcers). Unlike point prevalence, it describes only those individuals with pressure ulcers that were acquired within the facility after admission. An accurate facility-acquired pressure ulcer rate requires an accurate, documented skin assessment on admission to the facility for individuals in the defined population in order to exclude pre-existing pressure ulcers.¹

When interpreting pressure ulcer prevalence and incidence, consistency in the methods being compared is critical. While no particular method is more correct, facility-acquired pressure ulcer rates provide a better indication of the effectiveness of pressure ulcer prevention programs than raw prevalence rates. Incidence measures are even more suitable to measure effectiveness. Interpretation of prevalence and incidence studies is complicated by:¹⁻³

- the method used to calculate pressure ulcer rates (e.g., prevalence versus incidence);
- criteria used to define the study population (e.g. measurement setting, type of individual and their pressure ulcer risk);
- variations in time periods over which studies are conducted;
- definitions and classifications used for pressure ulcers (e.g., inclusion or otherwise of Category/Stage I pressure ulcers) ;
- strategies used to determine presence of a pressure ulcer (e.g., clinical assessment, patient report, documentation review); and
- random variation.

Included Literature

Pieper et al. (2012)⁴ recently published a comprehensive overview of pressure ulcer prevalence and incidence research published in peer review journals between January 1, 2000 and November 1, 2011 in a wide range of international clinical settings and populations. This information has been summarized throughout this chapter, with highlights reported, to provide a broad overview of trends in prevalence and incidence in a variety of health care settings. Studies reported in the review by Pieper et al. (2012)⁴ are listed following the references for this guideline section. In addition, prevalence and incidence studies published from November 1, 2011 to December 31, 2012 are reported as an update.

Prevalence and Incidence in Acute Care Settings

Sequential studies conducted in acute care settings and published since 2000 have reported pressure ulcer prevalence varying from 3.4% in one year of an eight year retrospective study conducted in 414 Dutch hospitals⁵ to 17.6% in a sample from 33 acute care units in a Swedish university hospital.⁶ In both cases, the point prevalence rate was attained following rigorous methods used for international and national benchmarking (i.e., the California Nursing Outcomes Coalition (CALNOC) hospitals methodology⁶ and the LPZ International methods⁵). However, the study reporting lowest prevalence rates⁵ did not include Category/Stage I pressure ulcers in the reporting. The lowest prevalence rates since 2000 that included Category/Stage I pressure ulcers was reported by Gunningberg et al. (2012)⁶, who found a prevalence of 6.3% in a sample from over 1,000 US acute care units in hospitals registered for CALNOC national benchmarking. Goldberg (2012)⁷ noted a drop of 1.2% in prevalence between 2008 and 2009, and the more recent data⁶ indicates a continuing trend in declining pressure ulcer prevalence.

Other studies published since the review by Goldberg (2012)⁷ published in Pieper et al. (2012)⁴ report prevalence rates consistent with the range identified over the preceding decade. Inan et al. (2012)⁸ conducted a cross sectional study of 404 individuals admitted to a university hospital in Turkey that reported point prevalence rate of 10.4% (95% confidence interval [CI] 7.4 to 13.4), with the most severe pressure ulcers located on the sacrum (43.9%) and trochanter (17.9%). WoundsWest conducted prevalence surveys in 86 Western Australian public hospitals in 2007, 2008, 2009 and 2011 and reported 10.9%, 12.5%, 9.5% and 11.0% respectively.⁹

Gunningberg et al. (2011)¹⁰ reported a point prevalence rate of 14.9% in a facility-wide survey of adults in two Swedish hospitals (n = 1,192) and Gunningberg et al. (2013)¹¹ reported point prevalence rate of 16.6% in a larger 2011 survey (n = 14,466) that included hospitals in 29 Swedish municipalities. Consistent with the conclusions of Pieper et al. (2012)⁴ that Category/Stage I and II pressure ulcers represent the vast majority of acute care pressure ulcers, these two Swedish studies reported 50% to 55% of the pressure ulcers identified were Category/Stage I.^{10, 11}

Overall, incidence rates of Category/Stage I to IV pressure ulcers in facility-wide acute care settings and published since the January 2000 of inclusion for the Goldberg (2012)⁷ review ranged from 2.8% in a small study (n=310) following participants for a period of four days length of stay¹² to 9% reported in a national US

survey following participants over five days length of stay.¹³ Both these studies were reported by Pieper et al. (2012)⁴, and newly published studies continue to report incidence rates within this range.

Molon et al. (2011)¹⁴ conducted a cross-sectional survey on an orthopedic unit in Brazil, including individuals over 19 years expected to be confined to chair or bed for at least five days and without pre-existing pressure ulcers (n = 43). The cumulative incidence of facility-acquired pressure ulcers within eight weeks of admission was 20%, with a median time to pressure ulcer development of seven days from admission. A major limitation of this study was the small sample size and that individuals who were not expected on admission to be confined to a bed or chair were excluded from the study. In their cross-sectional survey conducted in medical/surgical units, Gunningberg et al. (2012)⁶ reported facility-acquired pressure ulcer rates for Category/Stage III and IV pressure ulcers of 2.0% in general Swedish hospitals, 2.7% in university hospitals and 0.5% in CALNOC hospitals. In surveys conducted over four years in 86 Australian public hospitals, facility-acquired pressure ulcer rates reported in 2007, 2008, 2009 and 2011 were 7.8%, 9.3%, 6.3% and 7.4% respectively.⁹

Goldberg (2012)⁷ noted that incidence of deep tissue injury is a new area of study, and reported an incidence rate ranging from 0.3% established in 56 German facilities in 2008¹⁵ to 9% in two national US surveys.^{16, 17} Most recently, Gunningberg et al. (2012)⁶ highlighted that the US hospitals in their study categorized deep tissue injury slightly differently to the Swedish hospitals; however, the facility-acquired rates reported for Category/Stage III and IV pressure ulcers in both countries appear to include deep tissue injury.

Prevalence and Incidence in Aged Care Settings

Pieper (2012)¹⁸ included 34 prevalence and incidence studies conducted in long term care/nursing homes. Pressure ulcer incidence rates ranged from 3.6% to 59% and prevalence rates ranged from 4.1% to 32.2%. Four more recent studies conducted in aged care settings reported narrower ranges, with pressure ulcer prevalence rates reported from 9% to 14.5%^{11, 19, 20} and incidence rates of 1.9% to 5%.^{19, 21}

Igarashi et al. (2013)¹⁹ used a random selection of 135 long term care hospital wards in Japan to conduct a clinical audit of pressure ulcer incidence and prevalence. Incidence was reported at 1.9% ± 3.1%, and point prevalence was 9.5% ± 7.9%. The majority of pressure ulcers were Category/Stage II (40%) or Category/Stage III (38%). Prevalence of Category/Stage IV pressure ulcers was 7.3%. The majority of pressure ulcers were sacral (60.5%) or trochanteric (15.7%).

Moore et al. (2012)²⁰ conducted a cross-sectional clinical audit in 12 long term aged care facilities in Ireland and reported a pressure ulcer prevalence of 9%. More of the pressure ulcers in this study were classified as Category/Stage IV (24%) than in the study by Igarashi et al. (2013)¹⁹, which may relate to the different type aged care setting (long term care versus short term care). Moore et al. (2012)²⁰ found the sacrum (58%) and heel (25%) were the most common anatomical locations.

Gunningberg et al. (2013)¹¹ reported a point prevalence of 14.5% in nursing homes in Sweden. They also reported different prevalence rates according to type of nursing homes, with a prevalence rate of 12.3% in dementia-specific facilities and 21.9% in nursing homes specializing in short term care. In addition, 61.5% of the pressure ulcers occurring in the dementia care setting were classified as Category/Stage I compared with 47.7% of those occurring in the short term aged care setting.

Barba et al. (2011)²¹ highlighted that age of participants is a confounding factor to be considered in the analysis of prevalence and incidence rates of pressure ulcers in aged care settings. Their large database review that included over 1 million medical records of older adults discharged from internal medical departments in Spain reported a cumulative incidence of 5.0% in individuals aged over 90 years and 2.8% in those aged from 65 to 90 years. Moore et al. (2012)²⁰ also suggested that the “older old” experience a higher rate of pressure ulcers, with 56% of pressure ulcers identified in their audit occurring in the 80 to 89 year age group. The study by Igarashi et al. (2013)¹⁹, which reported a relatively low incidence rate of 1.9%, reported that the mean age of participants was only 50.2 ± 6.8 years despite being an aged care setting.

Prevalence and Incidence in Critical Care Settings

Cuddigan (2012)²² examined 23 prevalence, incidence and/or facility-acquired pressure ulcers studies published from 2000 to 2011 that included American, European and Pan-Pacific settings. Prevalence rates ranged from 13.1% in US intensive care units (ICUs) with less than 100 beds²³ to 45.5% in a study conducted in teaching hospitals in China.²⁴ No additional studies published following the Cuddigan (2012)²² review and reporting prevalence in critical care settings were identified.

Cuddigan (2012)²² reported incidence or facility-acquired rates in critical care settings ranging from 3.3% in a sample from two German hospitals²⁵ to 53.4% in Chinese teaching hospitals.²⁴

The data reported by Cuddigan (2012)²² indicated that facility-acquired pressure ulcer rates vary depending on the type of critical care setting (e.g., surgical ICU versus medical ICU) but are higher than rates observed in general acute care. One study published more recently confirmed this finding, reporting an average facility-acquired pressure ulcer rate of 5.0 per 1,000 patient days in the critical care unit compared with 1.1 per 1,000 patient days in the general acute care units in the same US hospital.²⁶

Prevalence and Incidence in Operating Room Settings

Ganos et al. (2012)²⁷ identified an incidence rate ranging from 5% in a sample of 498 individuals undergoing urological surgery in the US who were followed for 72 hours²⁸ to 53.4% in a sample of 109 patients undergoing cardiothoracic surgery in the Netherlands who were followed for 48 hours.²⁹ However, Ganos et al. (2012)²⁷ highlight that there is a significantly lower incidence rate (e.g., 0% to 1.4%) cited in studies investigating the effectiveness of pressure ulcer prevention interventions in this clinical setting, suggesting that significant and substantial reduction in pressure ulcers associated with surgery is a plausible aspiration.

Two more recently published studies were identified. Scarlatti et al. (2011)³⁰ conducted a longitudinal study including 199 surgery patients undergoing surgery of longer than two hours' duration in a hospital in Brazil. They reported a 20.6% incidence (95% confidence interval [CI] 15.2% to 26.9%). Pressure ulcers were primarily Category/Stage I or II (98.6%) and occurred most frequently on the trunk region (56.7%). Bulfone et al. (2012)³¹ followed a sample of 102 patients who underwent surgery of at least two hours' duration in an Italian teaching hospital. Overall pressure ulcer incidence was 12.7%, with higher rates observed in general surgery compared with vascular surgery (38.4% versus 15.3%).

Prevalence and Incidence in Pediatric Care

Baharestani (2012)³² reported the results from 24 pediatric pressure ulcer prevalence rate studies conducted in US, Europe and Pan-Pacific settings. The review cites prevalence rates ranging from 0.47% in a national US survey of hospitalized pediatric patients³³ to 72.5% in a small survey of a US pediatric outpatient service.³⁴ The highest prevalence reported in an inpatient setting was in a US survey of infants and children with spinal cord injury, 55% of whom had pressure ulcers of Category/Stage II or greater.³⁵

Only one pediatric prevalence study published since the review by Baharestani (2012)³² was identified. Schluer et al. (2012)³⁶ conducted a study in 14 pediatric hospitals in Switzerland (n = 412 children aged 24 hours to 18 years). The overall pressure ulcer prevalence was 35%, which is higher than quoted in previous literature. Eighty percent of the pressure ulcers were categorized as Category/Stage I. Prevalence rate was highest in the pediatric intensive care unit (PICU; 44%) and neonatology (43%).

Incidence of pressure ulcers in pediatric populations from 2000 to 2012 ranged from 0.25% in a study reporting Category/Stage III or greater pressure ulcers in a PICU in Ireland³⁷ to 27% in a multisite study set in US PICUs.³⁸ Medical device related pressure ulcers were reported in numerous pediatric studies cited by Baharestani (2012)³². Surveys of neonates receiving continuous positive airway pressure have reported ulcer rates from 32%³⁹ to 42.5%.⁴⁰ Most recently, the Swiss study by Schluer et al. (2012)³⁶ reported a medical device associated pressure ulcer rate of 40%.

As with other care settings, pediatric pressure ulcer prevalence and incidence rates vary significantly depending on population characteristics (e.g., chronic illness, disability or acute illness) and the care setting (e.g., community care, medical/surgical acute care or PICU). It is clear from this review that pressure ulcers are a significant concern in the pediatric population and preventive initiatives are very much needed, especially related to medical device related pressure ulcers.

Summary

Variations in methodological design and rigor continue to confound analysis of prevalence and incidence studies. There is a strong need for consistency in design and reporting in order to enable more reliable international benchmarking. Particularly where the effectiveness of pressure ulcer prevention programs is being investigated, facility-acquired pressure ulcer rates should be reported.

Table 1 provides a summary of the prevalence and incidence rate ranges reported in the literature from January 2000 to December 2012.

Table 1: Ranges of pressure ulcer prevalence and incidence reported in selected peer-reviewed literature published between 2000 and 2012.

Setting or Population	Prevalence Rates	Incidence & Facility-Acquired Rates
Acute care	0% ⁴¹ to 46% ⁴²	0% ⁴³ to 12% ⁴³
Critical care	13.1% ²³ to 45.5% ²⁴	3.3% ²⁵ to 53.4% ²⁹
Aged care	4.1% ⁴⁴ to 32.2% ⁴⁵	1.9% ¹⁹ to 59% ⁴⁶
Pediatric care	0.47% ³³ to 72.5% ³⁴	0.25% ³⁷ to 27% ³⁸
Operating room setting	—	5% ²⁸ to 53.4% ²⁹

An ongoing decline in pressure ulcer prevalence continues to be seen in the general acute care setting. Goldberg (2012)⁷ noted a declining trend in prevalence rates over the previous decade, and this trend continued in the most recent publications. In other clinical care settings, trends are less clear because significant variations in the study designs, specific setting descriptions, and population differences confound analyses.

In all clinical settings and populations, partial thickness pressure ulcers are more commonly observed than full thickness pressure ulcers. For example, in one recent operating room study, Category/Stage I pressure ulcers accounted for 98.6% of those observed.³⁰ With growing international health policy focus on the prevention of full thickness pressure ulcers, prevalence and incidence studies should clearly report pressure ulcers by Category/Stage.

In studies that reported anatomical location of pressure ulcers, the sacrum and heels were cited as the most common location and the location of the most severe pressure ulcers respectively.^{8, 10, 20, 47} This pattern was observed in most clinical settings; however, variation was seen in pediatric populations. In children and neonates, occipital and other head (including facial) pressure ulcers were commonly observed. The guideline chapter *Repositioning to Prevent and Treat Heel Pressure Ulcers* discusses specific interventions for preventing heel pressure ulcers, and sacral pressure ulcers receive noteworthy attention in the *Emerging Therapies for Prevention Ulcers* that includes the most recent research on prophylactic dressings. The *Special Populations: Pediatric Individuals* section of the guideline addresses specific strategies for preventing and managing pressure ulcers in younger individuals.

The impact of medical devices is a growing concern, particularly in pediatric populations. Medical devices have been associated with up to 34.5% of pressure ulcers in the acute care setting⁴⁸ and are estimated to account for 43% of pediatric pressure ulcers.⁴⁹ With minimal variation in rates of medical device related pressure ulcers reported over the past decade, this is a significant area for focus on prevention. The guideline chapter *Medical Device Related Pressure Ulcers* provides recommendations and timely guidance on prevention and management of device associated pressure ulcers.

Recommendations

Pressure ulcer prevalence and incidence studies provide valuable data to drive:

- quality improvement on a facility level;
- policy decisions on a national level; and
- research agendas on an international scale.

Unfortunately, significant variations in study methods and methodological rigor limit the value of these data in directing quality, policy and future research. These recommendations are based on sound epidemiological principles and are designed to guide greater consistency and rigor in the design, implementation and reporting of pressure ulcer prevalence and incidence studies in clinical settings.

1. Use a rigorous methodological design and consistent measurement variables when conducting pressure ulcer prevalence and incidence studies. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Prevalence and incidence studies should clearly report their methodological design. Attempts should be made to use a standardized methodology to allow risk adjustment and benchmarking. A rigorous study should include:

- clear definition of the study population prior to collecting data;
- provision of surveyor education,
- establishment of interrater reliability,
- skin inspections to categorize/stage pressure ulcers, and
- two surveyors per skin inspection.

Prevalence rates based on audit of medical records may be less reliable than data obtained from skin inspections conducted by qualified health professionals.

2. Compare results against organizational, national and/or international data sets (using a similar methodology) to develop a clearer understanding of pressure ulcer prevalence and incidence. (Strength of Evidence = C; Strength of Recommendation = 👍)

3. Use facility-acquired pressure ulcer rates (rather than prevalence rates) to evaluate pressure ulcer prevention programs. (Strength of Evidence = C; Strength of Recommendation = 👍)

Prevalence rates include all individuals in the facility/health service with pressure ulcers, including those with pressure ulcers that were present on admission to the health service. Facility-acquired pressure ulcer rates identify individuals with pressure ulcers that developed after admission; therefore these rates provide a better estimate of the adequacy of pressure ulcer preventive care within the facility. Prospective incidence measures would provide an even more accurate evaluation of prevention; however, this methodology is often too resource intensive for facilities to implement.

4. Present results by pressure ulcer risk level when reporting prevalence and incidence studies. (Strength of Evidence = C; Strength of Recommendation = 👍)

A simple description of pressure ulcer rates within various pressure ulcer risk levels may help refine quality improvement initiatives. It allows for more accurate comparison between facilities and may serve as a basis for risk adjustment. It is useful to distinguish population features that relate to pressure ulcer risk (e.g., mean age) in clinical settings that incorporate varying population profiles (e.g., critical care, aged care and pediatric units). A description of the population serviced by the facility can also assist in comparison (e.g., specifying the type of 'aged care facility', such as community dwelling older adults versus high level aged care).

5. Include the common anatomical locations of pressure ulcers when reporting prevalence and incidence studies. (Strength of Evidence = C; Strength of Recommendation = 👍)

Reporting pressure ulcer prevalence by anatomical location (e.g., sacrum, heels and occiput) can assist in identifying components of a pressure ulcer prevention program that may require more intensive resources and/or education.

- 6. Present results by Category/Stage and clearly indicate whether Category/Stage I pressure ulcers were included or excluded in the final calculation of prevalence and incidence rates. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Additionally, clearly indicate whether suspected deep tissue injuries are included in the reported prevalence and incidence rate, and how they were considered (e.g. combined with another Category/Stage).

- 7. Include, but do not categorize/stage mucosal membrane pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)**

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Additional References

General Acute Care Studies

The following studies were included in the analysis by Goldberg (2012)⁷. Pressure ulcer rates are taken from data extraction tables by Goldberg (2012)⁷. As discussed in this section of the guideline, a wide variety of factors influence reported prevalence and incidence rates. For context, please refer to the primary studies.

Amir Y, Meijers J, Halfens R. Retrospective study of pressure ulcer prevalence in Dutch general hospitals since 2001. *J Wound Care*. 2011;20(1):18, 20-5.

Prevalence: 3.4% to 8.5%

Baldelli P, Paciella M. Creation and implementation of a pressure ulcer prevention bundle improves patient outcomes. *Am J Med Qual*. 2008;23(2):136-42.

Incidence in acute care units: 7% to 12%; Prevalence in acute care units: 9% to 15%

Bales I, Duvendack T. Reaching for the moon: achieving zero pressure ulcer prevalence, an update. *J Wound Care*. 2011;20(8):374, 376-7.

HAPU: 0% to 4.2%; Prevalence: 4.7% to 9%

Bales I, Padwojski A. Reaching for the moon: achieving zero pressure ulcer prevalence. *J Wound Care*. 2009;18(4):137-44.

Annual incidence (2 years): 4% to 12%; Monthly prevalence (4 months): 0% to 9.5%

Black JM, Cuddigan JE, Walko MA, Didier LA, Lander MJ, Kelpel MR. Medical device related pressure ulcers in hospitalized patients. *Int Wound J*. 2010;7(5):358-65.

HAPU medical device related: 5.4%; Prevalence medical device related: 8.3% to 9.7%

Clark M, Bours G, Defloor T. Summary report on the prevalence of pressure ulcers. *EPUAP Rev*. 2002;4(2):49-57.

Incidence Category/Stage I: 42.1%; Prevalence: 8.3% to 22.9%

da Silva Cardoso J, Blanes L, Augusto Calil J, Ferreira Chacon JM, Masako Ferreira L. Prevalence of pressure ulcers in a Brazilian hospital: results of a cross-sectional study. *Ostomy Wound Manage*. 2010;56(10):52-7.

Hospital-wide prevalence: 10.3% to 11.4%

Elliott J. Are we reducing pressure ulcer incidence? An exploratory study by one acute trust. *J Tissue Viability*. 2009;18(4):125.

Incidence: 8.1%; Prevalence: 19.2%

Gallagher P, Barry P, Hartigan I, McCluskey P, O'Connor K, O'Connor M. Prevalence of pressure ulcers in three university teaching hospitals in Ireland. *J Tissue Viability*. 2008;17(4):103-9.

Point prevalence: 18.5%

Gunningberg L. EPUAP pressure ulcer prevalence survey in Sweden: a two-year follow-up of quality indicators. *J Wound Ostomy Continence Nurs*. 2006;33(3):258-66.

Hospital-wide prevalence: 10.9% to 14.1% (excluding Category/Stage I)

Hiser B, Rochette J, Philbin S, Lowerhouse N, Terburgh C, Pietsch C. Implementing a pressure ulcer prevention program and enhancing the role of the CWOCN: impact on outcomes. *Ostomy Wound Manage*. 2006;52(2):48-59.

Incidence: 6.6% to 9.2%; Prevalence in acute care units: 0% to 16%

House S, Giles T, Whitcomb J. Benchmarking to the International Pressure Ulcer Prevalence Survey. *J Wound Ostomy Continence Nurs.* 2011;38(3):254-9.

Incidence: 6.6%; Prevalence: 10%

Hurd T, Posnett J. Point prevalence of wounds in a sample of acute hospitals in Canada. *Int Wound J.* 2009;6(4):287-93.

Prevalence: 22.9%

James J, Evans JA, Young, T, Clark M. Pressure ulcer prevalence across Welsh orthopaedic units and community hospitals: surveys based on the European Pressure Ulcer Advisory Panel minimum data set. *Int Wound J.* 2010;7:147-52

Facility-wide prevalence: 26.7%

Jenkins ML, O'Neal E. Pressure ulcer prevalence and incidence in acute care. *Adv Skin Wound Care.* 2010;23(12):556-9.

Incidence: 2.8%; Prevalence: 15.8%

Johnson J, Peterston D, Campbell B, Richardson R, Rutledge D. Hospital-acquired pressure ulcer prevalence – evaluating low-air loss beds. *J Wound Ostomy Continence Nurs.* 2011;38(1):55-60.

Monthly HAPU: 1% to 3.3%

Keelaghan E, Margolis D, Zhan M, Baumgarten M. Prevalence of pressure ulcers on hospital admission among nursing home residents transferred to the hospital. *Wound Repair Regen.* 2008;16(3):331-6.

Prevalence: 6.6%

Kottner J, Dassen T, Lahmann N. Prevalence of deep tissue injuries in hospitals and nursing homes. Two cross-sectional studies. *Int J Nurs Stud.* 2010;47(6):665-70.

Incidence of DTI only in acute care: 0.3% to 0.5%; Prevalence: 6.4% to 7.1%

Kottner J, Wilborn D, Dassen T, Lahmann N. The trend of pressure ulcer prevalence rates in German hospitals: results of seven cross-sectional studies. *J Tissue Viability.* 2009;18(2):36-46.

Annual prevalence: 6.7% to 13.9%

Lahmann NA, Halfens RJ, Dassen T. Prevalence of pressure ulcers in Germany. *J Clin Nurs.* 2005;14(2):165-72.

Prevalence in nursing homes and hospitals: 11.7%

Langemo DK, Anderson J, Volden C. Uncovering pressure ulcer incidence. *Nurs Manage.* 2003;34(10):54-7.

Incidence in acute care units: 0% to 2%; Prevalence in acute care units: 0% to 4.1%

Lardenoye JW, Thieffaine JA, Breslau PJ. Assessment of incidence, cause, and consequences of pressure ulcers to evaluate quality of provided care. *Dermatol Surg.* 2009;35(11):1797-803.

Prevalence: 5.8%

Orsted HL, Rosenthal S, Woodbury MG. Pressure ulcer awareness and prevention program: a quality improvement program through the Canadian Association of Wound Care. *J Wound Ostomy Continence Nurs.* 2009;36(2):178-83.

Prevalence: 15% to 46% (explained reason)

Padula CA, Osborne E, Williams J. Prevention and early detection of pressure ulcers in hospitalized patients. *J Wound Ostomy Continence Nurs.* 2008;35(1):66-75.

HAPU: 0.07% to 0.05%

Robinson C, Gloeckner M, Bush S, et al. Determining the efficacy of a pressure ulcer prevention program by collecting prevalence and incidence data: a unit-based effort. *Ostomy Wound Manage.* 2003;49(5):44-6, 48-51.

Incidence 9% to 14%

Sanada H, Miyachi Y, Ohura T, et al. The Japanese pressure ulcer surveillance study: a retrospective cohort study to determine prevalence of pressure ulcers in Japanese hospitals. *Wounds.* 2008;20(6):176-82.

Prevalence: 4.26% to 3.64%

Santamaria N. Woundswest: identifying the prevalence of wounds within western Australia's public health system. *EWMA Journal*. 2009;9(3):13-18.

Prevalence: 11% to 12%

Tannen A, Dassen T, Halfens R. Response to Muurinen S et al. (2009) Commentary on Tannen A et al. (2008) Differences in prevalence of pressure ulcers between the Netherlands and Germany – associations between risk, prevention and occurrence of pressure ulcers in hospitals and nursing homes. *Journal of Clinical Nursing* 17, 1237-1244 in *Journal of Clinical Nursing* 18, 304-305. *J Clin Nurs*. 2009;18(10):1511-2.

Prevalence: 8.8% to 33%

Tubaishat A, Anthony D, Saleh M. Pressure ulcers in Jordan: a point prevalence study. *J Tissue Viability*. 2011;20(1):14-9.

Hospital-wide prevalence: 12%

Vanderwee K, Defloor T, Beeckman D, et al. Assessing the adequacy of pressure ulcer prevention in hospitals: a nationwide prevalence survey. *BMJ Qual Saf*. 2011;20(3):260-7.

Hospital-wide prevalence: 12.1%

VanGilder C, Amlung S, Harrison P, Meyer S. Results of the 2008-2009 International Pressure Ulcer Prevalence Survey and a 3-year, acute care, unit-specific analysis. *Ostomy Wound Manage*. 2009;55(11):39-45

Incidence: 6% to 6.4%; Prevalence: 9.1% to 13.7%

Vangilder C, MacFarlane GD, Harrison P, Lachenbruch C, Myer S. The Demographics of suspected deep tissue injury in the US: an analysis of the International Pressure Ulcer Prevalence Survey 2006-2009. *Adv Skin Wound Care*. 2010;23(6):254-61.

Monthly prevalence sDTI: 0.6% to 12.8%

Vangilder C, Macfarlane GD, Meyer S. Results of nine international pressure ulcer prevalence surveys: 1989 to 2005. *Ostomy Wound Manage*. 2008;54(2):40-54.

HAPU: 9.5%; Prevalence: 3% to 9%

Walsh N, Blanck A, Barret K. Pressure ulcer management in acute care setting: a response to regulatory mandates. *J Wound Ostomy Continence Nurs*. 2009;36(4):385-8.

Prevalence: 0.6% to 12.8%

Wann-Hansson C, Hagell P, Willman A. Risk factors and prevention among patients with hospital-acquired and pre-existing pressure ulcers in an acute care hospital. *J Clin Nurs*. 2008;17:1718-27.

Incidence on admission: 37%; HAPU: 49%

Whittington KT, Briones R. National prevalence and incidence study: 6 year sequential acute care data. *Adv Skin Wound Care*. 2004;17(9):490-4.

Prevalence: 7%

Wilborn D, Grittner U, Dassen T, Kottner J. The National Expert Standard Pressure Ulcer Prevention in Nursing and pressure ulcer prevalence in German health care facilities: a multilevel analysis. *J Clin Nurs*. 2010;19(23-24):3364-71.

Prevalence: 4.1% to 6.2%

Zafir B, Laor A, Bitterman H. Nonagenarians in internal medicine: characteristics, outcomes and predictors for in-hospital and postdischarge mortality. *Isr Med Assoc J*. 2010;12(1):10-5.

Prevalence: 21%

Zhao G, Hiltabidel E, Liu Y, Chen L, Liao Y. A cross-sectional descriptive study of pressure ulcer prevalence in a teaching hospital in China. *Ostomy Wound Manage*. 2010;56(2):38-42.

HAPU: 1.54%**Aged Care Studies**

The following studies were included in the analysis by Pieper (2012)¹⁸. Pressure ulcer rates are taken from data extraction tables by Pieper (2012)¹⁸. As discussed in this section of the guideline, a wide variety of factors influence reported prevalence and incidence rates. For context, please refer to the primary studies.

Abel RL, Warren K, Bean G, et al. Quality improvement in nursing homes in Texas: results from a pressure ulcer prevention project. *J Am Med Directors Assoc.* 2005;6:181-8.

Incidence: 10% to 13.6%; Prevalence: 26.9% to 32.2%

Barry T, Brannon D, Mor V. Nurse aide empowerment strategies and staff stability: effects on nursing home resident outcomes. *Gerontologist.* 2005;45(3):309-317.

Mean adjusted incidence: 1%:

Baumgarten M, Margolis D, Gruber-Baldini AL, et al. Pressure ulcers and the transition to long-term care. *Adv Skin Wound Care.* 2003;16(6):299-304.

Prevalence within 2 days of admission 10.3%

Baumgarten M, Margolis D, Van Doorn C, et al. Black/White differences in pressure ulcer incidence in nursing home residents. *J Am Geriatr Soc.* 2005;52:1293-8.

Prevalence on admission: 9.7%

Cai S, Mukamel DB, Temkin-Greener H. Pressure ulcer prevalence among black and white nursing home residents in New York state: evidence of racial disparity? *Med Care.* 2010;48(3):233-9.

Prevalence in high risk residents: 14.5%

Chacon JMF, Blanes L, Hochman B, Ferreira LM. Prevalence of pressure ulcers among the elderly living in long-stay institutions in Sao Paulo. *Sao Paulo Med J.* 2009;127(4):211.

Prevalence: 9.2% to 12.7%

Coleman EA, Martau JM, Lin M, Kramer AM. Pressure ulcer prevalence in long-term nursing home residents since the implementation of OBRA '87. *J Am Geriatr Soc.* 2002;50(4):728-32.

Prevalence: 8.52% to 8.54%

Comondore VR, Devereaux PJ, Zhou Q, et al. Quality of care in for-profit and not-for-profit nursing homes: systematic review and meta-analysis. *BMJ.* 2009;339:b2732.

Odds ratio: 0.9

Davis CM, Caseby NG. Prevalence and incidence studies of pressure ulcers two long-term care facilities in Canada. *Ostomy Wound Manage.* 2001;47(11):28-34.

Incidence: 11.6% to 11.7%

de Souza DMST, de Gouveia Santos VLC. Incidence of pressure ulcers in the institutionalized elderly. *J Wound Ostomy Continence Nurs.* 2010;37(3):272-6.

Incidence: 39.4%

Defloor T, De Bacquer D, Grypdonck MHF. The effect of various combinations of turning and pressure reducing devices on the incidence of pressure ulcers. *Int J Nurs Stud.* 2005;42(1):37-46.

Incidence: 42.4% to 47.6%

Dellefield ME. Prevalence rate of pressure ulcers in California nursing homes: using the OSCAR database to develop a risk-adjustment model. *J Gerontol Nurs.* 2004;30(11):13-21.

Mean prevalence: 8.58%

Di Giulio P, Toscani F, Villani D, Brunelli C, Gentile S, Spadin P. Dying with advanced dementia in long-term care geriatric institutions: a retrospective study. *J Palliat Med.* 2008;11(7):1023-8.

Prevalence among deceased patients: 47%

Gerardo MP, Teno, JM, Mor V. Not so black and white: nursing home concentration of Hispanics associated with prevalence of pressure ulcers. *J Am Med Directors Assoc.* 2009;10(2):127-32.

Prevalence Stage II to IV: 7.6% to 12.1%

Geyer MJ, Brienza DM, Karg P, Treffer E, Kelsey S. A randomized control trial to evaluate pressure-reducing seat cushions for elderly wheelchair users. *Adv Skin Wound Care.* 2001;14:120-9.

Sitting induced incident: 50% to 59%

Grabowski D, Angelelli J. The relationship of Medicaid payment rates, bed constraint policies, and risk-adjusted pressure ulcers. *Health Serv Res.* 2004;39(4 Pt1):793-812.

Incidence: 11.09%

Howard DL, Taylor YJ. Racial and gender differences in pressure ulcer development among nursing home residents in the Southeastern United States. *J Women Aging.* 2009;21(4):266-78.

Incidence stage II to IV: 3.4% to 4.7%

Kayser-Jones J, Kris AE, Lim K, Walent RJ, Halifax E, Paul SM. Pressure ulcers among terminally ill nursing home residents. *Res Gerontol Nurs.* 2008;1(1):14-24.

Incidence in those who were PU free on admission: 37.5%

Keelaghan E, Margolis D, Zhan M, Baumgarten M. Prevalence of pressure ulcers on hospital admission among nursing home residents transferred to the hospital. *Wound Repair Regen.* 2008;16(3):331-6.

Prevalence on admission: 66%

Kottner J, Dassen T, Lahmann N. Prevalence of deep tissue injuries in hospitals and nursing homes: two cross-sectional studies. *Int J Nurs Stud.* 2010;47(6):665-70.

Prevalence: 4.3% to 5.1%

Lahmann NA, Halfens RJG, Dassen T. Pressure ulcers in German nursing homes and acute care hospitals: prevalence, frequency, and ulcer characteristics. *Ostomy Wound Manage.* 2006;52(2):20-33.

Nursing home acquired pressure ulcer: 60.2% of all PU

Lahmann NA, Halfens RJG, Dassen T. Prevalence of pressure ulcers in Germany. *J Clin Nurs.* 2005;14:165-72.

Prevalence Stage I to IV: 11.8%; Prevalence Stage II to IV: 6.1%

Li Y, Yin J, Cai X, Temkin-Greener J, Mukamel DB. Association of race and sites of care with pressure ulcers in high-risk nursing home residents. *J Am Med Assoc.* 2011;306(2):179-86.

Prevalence in high risk groups: 9.6% to 16.8%

Lyder CH, Shannon R, Empleo-Frazier O, McGehee D, White C. A comprehensive program to prevent pressure ulcers in long-term care: exploring costs and outcomes. *Ostomy Wound Manage.* 2002;48(4):52-62.

Cumulative incidence: 28.5% to 42%; Prevalence on admission: 32%

McDermott-Scales L, Cowman S, Gethin G. Prevalence of wounds in a community care setting in Ireland. *J Wound Care.* 2009;18(10):405-17.

Prevalence: 26.3%

Sanada H, Miyachi Y, Ohura T, et al. The Japanese pressure ulcer surveillance study: a retrospective cohort study to determine prevalence of pressure ulcers in Japanese hospitals. *Wounds.* 2008;20(6):176-82.

Prevalence: 6.4% to 7.3%

Santangelo A, Testai M, Ossino MC, al. Management and treatment of decubital ulcers of an elderly population in the assisted sanitary residence of Futura-Viagrande (Catania, Sicily, Italy). *Arch Gerontol Geriatr.* 2009;48(3):332-334.

Prevalence: 42.5%

Siem CA, Wipke-Tevis DD, Rantz MJ, Popejoy LL. Skin assessment and pressure ulcer care in hospital-based skilled nursing facilities. *Ostomy Wound Manage.* 2003;49(6):42-58.

Prevalence on admission: 18.4%

Tannen A, Dassen T, Halfens R. Differences in prevalence of pressure ulcers between the Netherlands and Germany—associations between risk, prevention and occurrence of pressure ulcers in hospitals and nursing homes. *J Clin Nurs*. 2008;17:1237-1244.

Prevalence: 6.4% to 31.4%

Tannen A, Dietz E, Dassen T, Halfens R. (2009). Explaining the national differences in pressure ulcer prevalence between the Netherlands and Germany—adjusted for personal risk factors and institutional quality indicators. *J Eval Clin Practice*. 2009;15(1):85-90.

Prevalence: 8.3% to 30.8%

Thompson P, Langemo D, Anderson J, Hanson D, Hunter S. Skin care protocols for pressure ulcers and incontinence in long-term care: a quasi-experimental study. *Adv Skin Wound Care*. 2005;18:422-9.

Incidence: 8.9% to 32.7%; Prevalence: 4.8% to 11.3%

Tippet AW. Reducing the incidence of pressure ulcers in nursing home residents: a prospective 6-year evaluation. *Ostomy Wound Manage*. 2009;55(11):52-8.

Average incidence: 0.73% to 5.19%

VanGilder C, MacFarlane GD, Meyer S. Results of nine international pressure ulcer prevalence surveys: 1989 to 2005. *Ostomy Wound Manage*. 2008;54(2):40-54.

Prevalence: 9.2% to 15.2%

Wilborn D, Grittner U, Dassen T, Kottner J. The National Expert Standard Pressure Ulcer Prevention in Nursing and pressure ulcer prevalence in German health care facilities: a multilevel analysis. *J Clin Nurs*. 2010;19(23-24):3364-71.

Prevalence: 4.1% to 6.2%

Critical Care Studies

The following studies were included in the analysis by Cuddigan (2012)²². Pressure ulcer rates are taken from data extraction tables by Cuddigan (2012)²². As discussed in this section of the guideline, a wide variety of factors influence reported prevalence and incidence rates. For context, please refer to the primary studies.

Boyle M, Green M. Pressure sores in intensive care: defining their incidence and associated factors and assessing the utility of two pressure sore risk assessment tools. *Aust Crit Care*. 2001;14:24-30.

Incidence: 5.2%

Cho I, Noh M. Braden Scale: evaluation of clinical usefulness in an intensive care unit. *J Adv Nurs*. 2010;66:293-302.

Incidence: 5.9%

Compton F, Hoffmann F, Hortig T, et al. Pressure ulcer predictors in ICU patients: nursing skin assessment versus objective parameters. *J Wound Care*. 2008;17:417-20, 422-4.

Incidence: 17.3%

da Silva Cardoso JR, Blanes L, Augusto Calil J, Ferreira Chacon JM, Masako Ferreira L. Prevalence of pressure ulcers in a Brazilian hospital: results of a cross-sectional study. *Ostomy Wound Manage*. 2010;56:52-7.

ICU prevalence: 32.7%

Fife C, Otto G, Capsuto EG, et al. Incidence of pressure ulcers in a neurologic intensive care unit. *Crit Care Med*. 2001;29:283-90.

Incidence: 12.4%

Gomes FSL, Bastos MAR, Matozinhos FP, Temponi HR, Velasquez-Melendez G. [Factors associated to pressure ulcers in patients at adult Intensive Care Units]. *Rev Esc Enferm USP*. 2010;44:1070-6.

Incidence: 35.2%

Kaitani T, Tokunaga K, Matsui N, Sanada H. Risk factors related to the development of pressure ulcers in the critical care setting. *J Clin Nurs*. 2010;19:414-21.

Incidence: 11.2%

Langemo DK, Anderson J, Volden C. Uncovering pressure ulcer incidence. *Nurs Manage*. 2003;34:54-7.

HAPU: 0% to 2.8%; Prevalence: 0% to 13.1%

Manzano F, Navarro MJ, Roldan D, et al. Pressure ulcer incidence and risk factors in ventilated intensive care patients. *J Crit Care*. 2010;25:469-76.

Incidence: 16%

Nijs N, Toppets A, Defloor T, Bernaerts K, Milisen K, Van Den Berghe G. Incidence and risk factors for pressure ulcers in the intensive care unit. *J Clin Nurs*. 2009;18:1258-66.

Cumulative incidence: 20.1%

Sayar S, Turgut S, Dogan H, et al. Incidence of pressure ulcers in intensive care unit patients at risk according to the Waterlow scale and factors influencing the development of pressure ulcers. *J Clin Nurs*. 2009;18:765-74.

Incidence: 8.5%

Schuurman JP, Schoonhoven L, Keller BP, van Ramshorst B. Do pressure ulcers influence length of hospital stay in surgical cardiothoracic patients? A prospective evaluation. *J Clin Nurs*. 2009;18:2456-63.

ICU acquired: 53.4%

Shahin ES, Dassen T, Halfens RJ. Incidence, prevention and treatment of pressure ulcers in intensive care patients: a longitudinal study. *Int J Nurs Stud*. 2009;46:413-21.

Incidence: 3.3%; Prevalence on admission: 13.2%

Shahin ES, Dassen T, Halfens RJ. Pressure ulcer prevalence in intensive care patients: a cross-sectional study. *J Eval Clin Pract*. 2008;14:563-8.

Prevalence including Stage I: 25.1% to 28.6%

Shahin ES, Dassen T, Halfens RJ. Pressure ulcer prevention in intensive care patients: guidelines and practice. *J Eval Clin Pract*. 2009;15:370-4.

Prevalence: 27.2%

Slowikowski GC, Funk M. Factors associated with pressure ulcers in patients in a surgical intensive care unit. *J Wound Ostomy Continence Nurs*. 2010;37:619-26.

HAPU: 23.9%

Suriadi, Sanada H, Sugama J, Thigpen B, Subuh M. Development of a new risk assessment scale for predicting pressure ulcers in an intensive care unit. *Nurs Crit Care*. 2008;13:34-43.

Prevalence: 28.4%

Terekeci H, Kucukardali Y, Top C, Onem Y, Celik S, Oktenli C. Risk assessment study of the pressure ulcers in intensive care unit patients. *Eur J Intern Med*. 2009;20:394-7.

Incidence: 7.8% to 8.5%

Vangilder C, Amlung S, Harrison P, Meyer S. Results of the 2008 - 2009 International Pressure Ulcer Prevalence Survey and a 3-year, acute care, unit-specific analysis. *Ostomy Wound Manage*. 2009;55:39-45.

HAPU: 4.3% to 12.1%; Prevalence: 11.2% to 20.7%

Vangilder C, Macfarlane GD, Meyer S. Results of nine international pressure ulcer prevalence surveys: 1989 to 2005. *Ostomy Wound Manage*. 2008;54:40-54.

HAPU: 7.3% to 15.3%; Prevalence: 14.6% to 25.9%

Wolverton CL, Hobbs LA, Beeson T, et al. Nosocomial pressure ulcer rates in critical care: performance improvement project. *J Nurs Care Qual.* 2005;20:56-62.

Prevalence: 13.7%

Yepes D, Molina F, Leon W, Perez E. [Incidence and risk factors associated with the presence of pressure ulcers in critically ill patients]. *Med Intensiva.* 2009;33:276.

Incidence: 26.7%

Zhao G, Hiltabidel E, Liu Y, Chen L, Liao Y. A cross-sectional descriptive study of pressure ulcer prevalence in a teaching hospital in China. *Ostomy Wound Manage.* 2010;56:38-42.

HAPU: 1.54%; ICU prevalence: 45.5%

Studies in the Operating Room

The following studies were included in the analysis by Ganos et al. (2012)²⁷. Pressure ulcer rates are taken from data extraction tables by Ganos et al. (2012)²⁷. As discussed in this section of the guideline, a wide variety of factors influence reported prevalence and incidence rates. For context, please refer to the primary studies.

Carneiro GA, Leite Rde C. Skin lesions in the intraoperative period of cardiac surgery: incidence and characterization. [Portuguese]. *Revista da Escola de Enfermagem da USP.* 2011;45(3):611-16.

Incidence: 20.9%; Prevalence: 0.5%

Chalian AA, Kagan SH. Backside first in head & neck surgery? Preventing pressure ulcers in extended length surgeries. *Head Neck.* 2001;23(1):25-8.

Incidence: 0% to 21%; Prevalence: 21%

Conner T, Sledge JA, Bryant-Wiersema L, Stamm L, Potter P. Identification of pre-operative and intra-operative variables predictive of pressure ulcer development in patients undergoing urologic surgical procedures. *Urol Nurs.* 2010;30(5):289-95.

Incidence: 5%

Feuchtinger J, de Bie R, Dassen T, Halfens R. A 4-cm thermoactive viscoelastic foam pad on the operating room table to prevent pressure ulcer during cardiac surgery. *J Clin Nurs.* 2006;15(2):162-7.

Incidence: 11.1% to 17.6%; Prevalence: 2.3%

Feuchtinger J, Halfens R, Dassen T. Pressure ulcer risk assessment immediately after cardiac surgery - does it make a difference? A comparison of three pressure ulcer risk assessment instruments within a cardiac surgery population. *Nurs Crit Care.* 2007;12(1):42-9.

Incidence: 49%

Goodwin CR, Recinos PF, Omeis I, et al. Prevention of facial pressure ulcers using the Mayfield clamp for sacral tumor resection. *J Neurosurg Spine.* 2011;14(1):85-7.

Incidence: 0%

Grisell M, Place HM. Face tissue pressure in prone positioning: a comparison of three face pillows while in the prone position for spinal surgery. *Spine.* 2008;33(26):2938-41.

Incidence: 0% to 31.3%; Prevalence: 9%

Nixon J, Brown J, McElvenny D, Mason S, Bond S. Prognostic factors associated with pressure sore development in the immediate post-operative period. *Int J Nurs Stud.* 2000;37(4):279-89.

Incidence: 15.6%; Prevalence: 10.3%

Nixon J, Cranny G, Bond S. Skin alterations of intact skin & risk factors associated with pressure ulcer development in surgical patients: a cohort study. *Int J Nurs Stud.* 2007;44(5): 655-63.

Incidence: 15.5%; Prevalence: 3.8%

Pokorny ME, Kodjeski D, Swanson M. Skin care intervention for patients having cardiac surgery. *Am J Crit Care.* 2003;12(6):535-44.

Incidence: 7%; Prevalence in a cardiac surgery step down unit and ICU: 10% to 40%

Russell JA, Lichtenstein SL. Randomized controlled trial to determine the safety and efficacy of a multi-cell pulsating dynamic mattress system in the prevention of pressure ulcers in patients undergoing cardiovascular surgery. *Ostomy Wound Manage.* 1. 2000;46(2):46-51, 54-5.

Incidence: 2% to 7%

Schuurman JP, Schoonhoven L, Keller BP, van Ramshorst B. Do pressure ulcers influence length of hospital stay in surgical cardiothoracic patients? A prospective evaluation. *J Clin Nurs.* 2009;18(17):2456-63.

Incidence: 53.4%

Scott EM. The prevention of pressure ulcers in the operating department. *J Wound Care.* 2000;9(1):18-21.

Incidence: 5% to 13.7%

Stevens J, Nicholson E, Linehan WM, et al. Risk factors for skin breakdown after renal and adrenal surgery. *Urology.* 2004;64(2):246-9.

Incidence: 14.4%

Pediatric Care Studies

The following studies were included in the analysis by Baharestani (2012)³². Pressure ulcer rates are taken from data extraction tables by Baharestani (2012)³² and are indicative only. As discussed in this section of the guideline, a wide variety of factors influence reported prevalence and incidence rates. For context, please refer to the primary studies.

Baldwin KM. Incidence and prevalence of pressure ulcers in children. *Adv Skin Wound Care.* 2002;15(3):121-4.

Incidence: 0.29%; Prevalence: 0.47%

Buettiker V, Hug MI, Baenziger O, Meyer C, Frey B. Advantages and disadvantages of different nasal CPAP systems in newborns. *Intensive Care Med.* 2004;30(5):926-30.

Device-related incidence: 40%

Curley MA, Quigley SM, Lin M. Pressure ulcers in pediatric intensive care: incidence and associated factors. *Pediatr Crit Care Med.* 2003;4(3):284-90.

Incidence: 27%

Dixon M, Ratliff C. Pediatric pressure ulcer prevalence – one hospital's experience. *Ostomy Wound Manage.* 2005;51(6):44-50.

Prevalence: 3% to 4%

Fischer C, Bertelle V, Hohlfeld J, Forcada-Guex M, Stadelmann-Diaw C, Tolsa JF. Nasal trauma due to continuous positive airway pressure in neonates. *Arch Dis Child Fetal Neonatal Ed.* 2010;95(6):F447-F451.

Device related incidence: 42.5%

Fujii K, Sugama J, Okuwa M, Sanada H, Mizokami Y. Incidence and risk factors of pressure ulcers in seven neonatal intensive care units in Japan: a multisite prospective cohort study. *Int Wound J.* 2010;7(5):323-28.

Cumulative incidence: 16%

Groeneveld A, Anderson M, Allen S, et al. The prevalence of pressure ulcers in a tertiary care pediatric and adult hospital. *J Wound Ostomy Continence Nurs.* 2004;31(3):108-20.

Prevalence: 13.1%

Gunlemez A, Isken T, Gokalp AS, Turker G, Arisoy EA. Effect of silicon gel sheeting in nasal injury associated with nasal CPAP in preterm infants. *Indian Pediatr.* 2010;47(3):265-7.

Device-related incidence: 9.5%

Hickey KJ, Anderson CJ, Vogel LC. Pressure ulcers in pediatric spinal cord injury. *Top Spinal Cord Inj Rehabil.* 2000; 6(Suppl 1):85-90.

Prevalence: 21.6% to 55%

Jatana KR, Oplatek A, Stein, M, Phillips G., Kang DR. Effects of nasal continuous positive airway pressure and cannula use in the neonatal intensive care unit setting. *Arch Otolaryngol Head Neck Surg.* 2010;136(3):287-91.

Incidence: 13.2%

Kottner J, Wilborn D, Dassen T. Frequency of pressure ulcers in the paediatric population: a literature review and new empirical data. *Int J Nurs Stud.* 2010;47(10):1330-40.

Incidence: 7%; PICU incidence: 26% Prevalence Stage I to IV: 2% to 28%

Ligi I, Arnaud F, Jouve E, Tardieu S, Sambuc R, Simeoni U. Iatrogenic events in admitted neonates: a prospective cohort study. *Lancet.* 2008; 371(9610):404-10.

Device-related incidence: 6%

McLane KM, Bookout K, McCord S, McCain J, Jefferson LS. The 2003 national pediatric pressure ulcer and skin breakdown prevalence survey: a multisite study. *J Wound Ostomy Continence Nurs.* 2004;31(4):168-78.

Prevalence: 4% (26% of these were in neonates); HAPU prevalence rate 2.7%

Murdoch V. Pressure care in the paediatric intensive care unit. *Nurs Stand.* 2002;17(6):71-4, 76.

Incidence: 0.25% to 0.9%

Noonan C, Quigley S, Curley MAQ. Skin integrity in hospitalized infants and children: a prevalence study. *J Pediatr Nurs.* 2006; 21(6):445-53.

Prevalence: 1.6%

Pieper B, Templin T, Dobal M, Jacox A. Prevalence and types of wounds among children receiving care in the home. *Ostomy Wound Manage.* 2000;46(4):36-42.

Prevalence: 5.9%

Rego MAC, Martinez FE. Comparison of two nasal prongs for application of continuous positive airway pressure in neonates. *Pediatr Crit Care Med.* 2002;3(3):239-43.

Device-related incidence: 27% to 32%

Samaniego IA. A sore spot in pediatrics: risk factors for pressure ulcers. *Pediatr Nurs.* 2003;29(4):278-82.

Prevalence: 72.5% (44% of these were device-related)

Schindler CA, Mikhailov TA, Fischer K, Lukasiewicz G, Kuhn EM, Duncan L. Skin integrity in critically ill and injured children. *Am J Crit Care.* 2007;16(6):568-74.

Incidence: 18%

Schindler CA, Mikhailov TA, Kuhn EM, et al. Protecting fragile skin: decrease development of pressure ulcers in pediatric intensive care. *Am J Crit Care.* 2011;20(1):26-34.

Aggregate incidence: 0.8% to 17.5%

Schluer AB, Cignacco E, Muller M, Halfens, RJ. The prevalence of pressure ulcers in four paediatric institutions. *J Clin Nurs.* 2009;18(23):3244-52.

Prevalence: 27.7%

Suddaby EC, Barnett SD, Facticeau L. Skin breakdown in acute care pediatrics. *Dermatol Nurs.* 2006;18(2):155-61.

Prevalence: 23%; PICU prevalence: 42%

Willock J, Harris C, Harrison J, Poole C. Identifying the characteristics of children with pressure ulcers. *Nurs Times.* 2005;101(11):40-3.

50% of identified PU were device-related

Yong SC, Chen SJ, Boo NY. Incidence of nasal trauma associated with nasal prong versus nasal mask during continuous positive airway pressure treatment in very low birthweight infants: a randomised control study. *Arch Dis Child Fetal Neonatal Ed.* 2005;90(6):F480- F483.

Device-related incidence: 33%

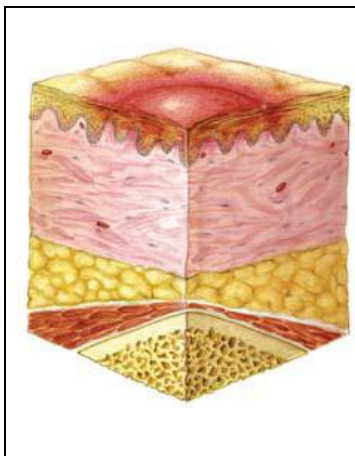
INTERNATIONAL NPUAP/EPUAP PRESSURE ULCER CLASSIFICATION SYSTEM

A pressure ulcer is localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear. A number of contributing or confounding factors are also associated with pressure ulcers; the significance of these factors is yet to be elucidated.

Category/Stage I: Nonblanchable Erythema

Intact skin with non-blanchable redness of a localized area usually over a bony prominence. Darkly pigmented skin may not have visible blanching; its color may differ from the surrounding area.

The area may be painful, firm, soft, warmer or cooler as compared to adjacent tissue. Category/Stage I may be difficult to detect in individuals with dark skin tones. May indicate "at risk" individuals (a heralding sign of risk).

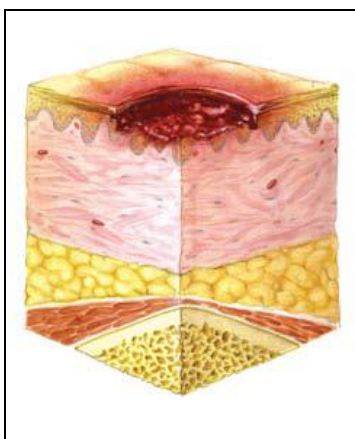


Category/Stage II: Partial Thickness Skin Loss

Partial thickness loss of dermis presenting as a shallow open ulcer with a red pink wound bed, without slough. May also present as an intact or open/ruptured serum-filled blister.

Presents as a shiny or dry shallow ulcer without slough or bruising.* This Category/Stage should not be used to describe skin tears, tape burns, perineal dermatitis, maceration or excoriation.

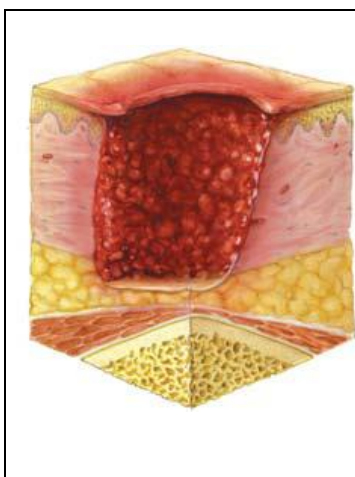
*Bruising indicates suspected deep tissue injury.



Category/Stage III: Full Thickness Skin Loss

Full thickness tissue loss. Subcutaneous fat may be visible but bone, tendon or muscle are not exposed. Slough may be present but does not obscure the depth of tissue loss. May include undermining and tunneling.

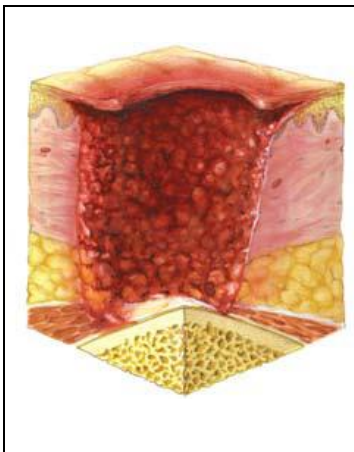
The depth of a Category/Stage III pressure ulcer varies by anatomical location. The bridge of the nose, ear, occiput and malleolus do not have subcutaneous tissue and Category/Stage III ulcers can be shallow. In contrast, areas of significant adiposity can develop extremely deep Category/Stage III pressure ulcers. Bone/tendon is not visible or directly palpable.



Category/Stage IV: Full Thickness Tissue Loss

Full thickness tissue loss with exposed bone, tendon or muscle. Slough or eschar may be present on some parts of the wound bed. Often include undermining and tunneling.

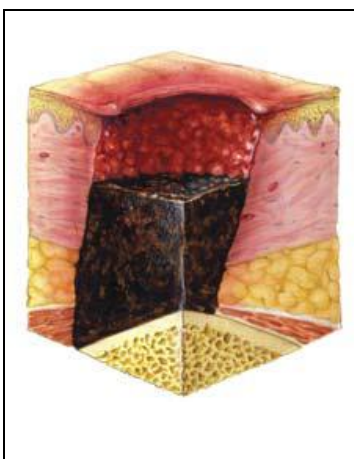
The depth of a Category/Stage IV pressure ulcer varies by anatomical location. The bridge of the nose, ear, occiput and malleolus do not have subcutaneous tissue and these ulcers can be shallow. Category/Stage IV ulcers can extend into muscle and/or supporting structures (e.g., fascia, tendon or joint capsule) making osteomyelitis possible. Exposed bone/tendon is visible or directly palpable.



Unstageable: Depth Unknown

Full thickness tissue loss in which the base of the ulcer is covered by slough (yellow, tan, gray, green or brown) and/or eschar (tan, brown or black) in the wound bed.

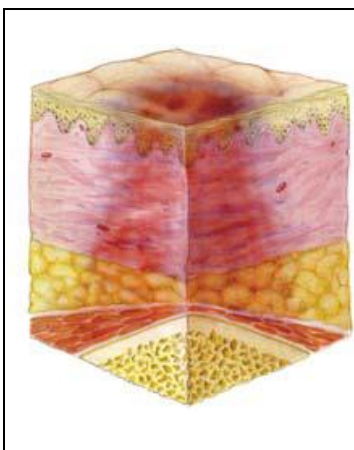
Until enough slough and/or eschar is removed to expose the base of the wound, the true depth, and therefore Category/Stage, cannot be determined. Stable (dry, adherent, intact without erythema or fluctuance) eschar on the heels serves as 'the body's natural (biological) cover' and should not be removed.



Suspected Deep Tissue Injury: Depth Unknown

Purple or maroon localized area of discolored intact skin or blood-filled blister due to damage of underlying soft tissue from pressure and/or shear. The area may be preceded by tissue that is painful, firm, mushy, boggy, warmer or cooler as compared to adjacent tissue.

Deep tissue injury may be difficult to detect in individuals with dark skin tones. Evolution may include a thin blister over a dark wound bed. The wound may further evolve and become covered by thin eschar. Evolution may be rapid exposing additional layers of tissue even with optimal treatment.



PREVENTION OF PRESSURE ULCERS

RISK FACTORS AND RISK ASSESSMENT

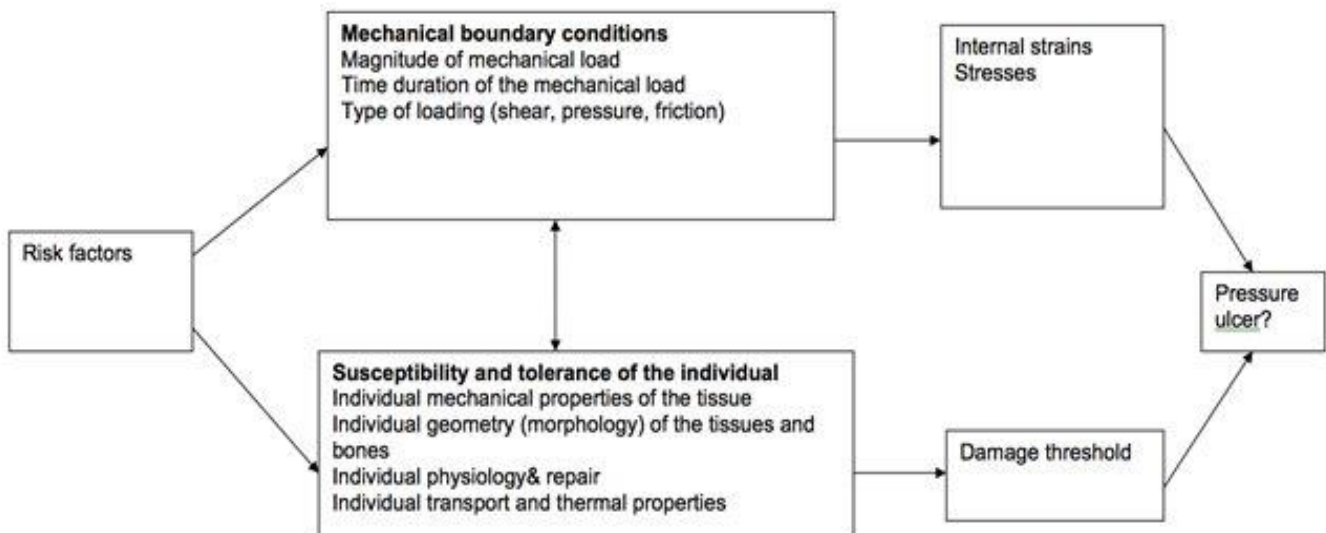
Introduction

Risk assessment is a central component of clinical practice aimed at identifying individuals susceptible to pressure ulcers in order to target appropriate interventions and prevent pressure ulcer development. The following section of the guideline addresses risk factors for pressure ulcers and risk assessment in adult populations. The *Special Populations: Pediatric Individuals* section of the guideline addresses risk factors and risk assessment in neonates and children.

Individuals with activity/mobility limitations are at risk of developing pressure ulcers (see also the *Etiology of Pressure Ulcers* section of this guideline). The challenge in clinical practice is to identify individuals with characteristics that increase the probability of pressure ulcer development. Individuals who are at high risk are those characterized by multiple risk factors that affect both the mechanical boundary conditions (i.e., the type, magnitude, time and duration of the mechanical load) and the susceptibility and tolerance of the individual (i.e., individual mechanical properties, geometry, physiology and repair, and transport and thermal properties of the tissues), as detailed in *Figure 1*. Examples of high risk individuals include:

- older adults,
- those who have experienced trauma,
- those with spinal-cord injuries (SCI),
- those who have sustained a fractured hip,
- those in long-term homes or community care,
- the acutely ill,
- individuals with diabetes, and
- those in critical care settings.

Figure 1: Factors influencing the susceptibility of an individual for developing pressure ulcers (adapted from Oomens (1985)¹, used with permission in 2009 guideline, continuing work produced this modification which is published in Coleman et al. (2013)²; reproduced with permission)



Epidemiological research has increased considerably in recent years, providing a better understanding of risk factors important in the development of pressure ulcers for each individual.² In addition, there has been a plethora of risk assessment tools developed for use in clinical practice, with clinical evaluation of their ability to identify those at high risk.³ This literature has been systematically reviewed in order to address the following questions:

1. What characteristics of the individual increase the probability of pressure ulcer development?
2. Does the use of risk assessment tools confer any benefits in the prevention of pressure ulcer development over clinical judgment?
3. What is the reliability of risk assessment tools?
4. What is the validity of risk assessment tools?

The methodological considerations for epidemiological studies used to identify risk factors and studies to determine the reliability and predictive validity of risk assessment tools differ from those of the intervention studies used throughout much of this guideline. There are, therefore, distinct review methods to address questions 1, 3 and 4 as stated above, with an exception made to guideline statement developments which are based on two published systematic reviews and updated literature.^{2,3} Refer to *Appendix 1: Guideline Methodology* section of the guideline and the summary of evidence below.

General Recommendations for Structured Risk Assessment

1. **Conduct a structured risk assessment as soon as possible (but within a maximum of eight hours after admission) to identify individuals at risk of developing pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
2. **Repeat the risk assessment as often as required by the individual's acuity. (Strength of Evidence = C; Strength of Recommendation = 👍)**
3. **Undertake a reassessment if there is any significant change in the individual's condition. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These statements are based on expert opinion. Due to the burden and impact of pressure ulcer development on both the individual and the health service, it is accepted practice that risk assessment should be undertaken on individuals, with the aim of identifying those who are at potential risk in order that individualized preventive interventions can be planned and initiated. Risk assessments should be conducted **as soon as possible**, but within a maximum of eight hours after admission (i.e., at first contact with the health professional) or at first visit in community settings.

An individual's level of pressure ulcer risk may change with alterations in health status. These changes may occur over time, and should be monitored regularly. Sudden changes in the individual's condition may result in increased risk and vulnerability to pressure damage. Health professionals must be alert and identify changes in the level of risk, as prevention strategies may need to be intensified accordingly.

4. **Include a comprehensive skin assessment as part of every risk assessment to evaluate any alterations to intact skin. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion and indirect evidence. As noted in the guideline section, *Skin and Tissue Assessment*, a comprehensive skin assessment should be part of every risk assessment. Skin and risk assessment are inextricably linked. There is strong epidemiological evidence that alterations in skin status are associated with both the progression of existing pressure ulcers and the development of new pressure ulcers, making skin assessment an essential part of any risk assessment. (See below for a discussion of skin status as a risk factor for pressure ulcers). Results of a comprehensive skin assessment are also essential in developing an individualized plan for prevention.

5. **Document all risk assessments. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Accurate documentation is essential. Documentation of risk assessments ensures communication within the multidisciplinary team, provides evidence that care planning is appropriate, and serves as a benchmark for monitoring the individual's progress.⁴⁻⁶

6. **Develop and implement a risk based prevention plan for individuals identified as being at risk of developing pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Caution: Do not rely on a total risk assessment tool score alone as a basis for risk based prevention. Risk assessment tool subscale scores and other risk factors should also be examined to guide risk-based planning.

This statement is based upon expert opinion. Once individuals are identified as being at risk of pressure ulcer development, a prevention program should be developed that aims to minimize the impact of factors identified as increasing the individual's pressure ulcer risk. Failing to provide appropriate prevention strategies when an individual has been identified to be at risk of pressure ulcer development is a failure in the duty of care owed by the health professional and can be deemed as negligence, except in situations where pressure ulcer prevention strategies are not consistent with the individual's wishes (see the guideline section *Special Populations: Individuals In Palliative Care*). The rationale of care should be explained to the individual and the agreed plan of care documented.

Recent research on pressure ulcer prevention has focused on programs to reduce risk. Risk reduction programs combine risk assessment with components tailored to the individual's unique risk profile. The guideline section *Implementing the Guideline: Facilitators, Barriers and Implementation Strategy* provides a comprehensive overview on the effectiveness of risk reduction programs and components to consider in their implementation.

Total risk assessment tool scores provide general information on risk status and level of risk. Pressure ulcer incidence progressively increases with increasing level of risk based on Braden Scale total scores.⁷ ⁸ Total Braden Scale scores⁹⁻¹⁵ and Norton Scale scores¹⁶ have emerged as statistically significant factors in some multivariable models. However, total scores do not provide sufficient information for developing individualized risk-based prevention plans and do not assess all relevant risk factors. Subscale scores and other risk factors should also be examined to guide risk-based planning and more effective utilization of resources.

Structured Risk Assessment

1. **Use a structured approach to risk assessment that is refined through the use of clinical judgment and informed by knowledge of relevant risk factors. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

There is no universally agreed best approach for conducting a risk assessment; however, expert consensus³ suggests that the approach be 'structured' in order to facilitate consideration of all relevant risk factors. This guideline provides a summary of key considerations in a structured risk assessment. The first approach involves consideration of characteristics of the individual that increase the probability of pressure ulcer development that have been identified through a comprehensive review of current epidemiological evidence. The second involves consideration of risk assessment tools that incorporate many, but not all, relevant risk factors. Regardless of the structured approach used, clinical judgment is a necessary component of any risk assessment.

Risk Factor Assessment

Our systematic search of the literature to address the question of what characteristics of the individual increase the probability of pressure ulcer development identified one systematic review² comprising 54 studies⁹⁻⁶² and a further 15 risk factor studies^{8, 12, 63-75} identified in the guideline search update. Factors that

have been explored and that emerge in multivariable risk factor modeling as statistically independent risk factors are reported in this section of the guideline.

A review of the epidemiological evidence identifies a number of key risk factor domains associated with the development of pressure ulcers. The literature provides a basis for generic guideline statements regarding risk factor domains that are important in pressure ulcer development. However, the large number of risk factor descriptors utilized in the 69 cohort studies that were identified provides a confusing landscape in terms of how some of the risk factors may be assessed in the clinical setting.

In practice, risk assessment tools have been developed to provide structure and operational definitions for assessment of many of the key risk factors, and these are supplemented by advanced and specialized knowledge which informs clinical judgment. However, it is also acknowledged that some risk factors are not currently considered or operationally defined (e.g., perfusion and oxygenation, as discussed below) and translation into practice requires further development work. In addition, the strength and quality of evidence is variable for each risk factor. Risk factors are presented according to their supporting strength of evidence. Any structured approach to risk assessment should consider all these factors.

- 1. Use a structured approach to risk assessment that includes assessment of activity/mobility and skin status. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

Activity and Mobility Limitations

- 1.1. Consider bedfast and/or chairfast individuals to be at risk of pressure ulcer development. (Strength of Evidence = B; Strength of Recommendation = 👍)**
- 1.2. Consider the impact of mobility limitations on pressure ulcer risk. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

These statements are underpinned by high quality epidemiological evidence, bioengineering principles/research and the etiological framework. Immobility descriptors emerge consistently in multivariable modeling demonstrating a strong statistical association between activity and mobility limitations and the development of new pressure ulcers (see *Table 1*).


Being bedfast or chairfast are usually described as limitations of activity. A reduction in an individual's frequency of movement or ability to move is usually described as having a mobility limitation. In terms of the underlying conceptual framework, mobility and activity limitations directly impact upon mechanical boundary conditions (see *Figure 1*) and exposure to pressure, shear and resulting frictional forces.

Epidemiological studies consistently identify that activity/mobility limitations increase the probability of pressure ulcer development (Level 2 and 4 studies). Overall, 48 studies entered one or more measure of mobility/activity into multivariable modeling and in 34 (70.8%) of these studies a measure of activity/mobility emerged. Indicators of activity/mobility limitations include descriptors, scales and measures (see *Table 1*) indicative of exposure to abnormal mechanical loads including:^{2, 8, 63-65, 67, 69, 70, 74}

- Mobility/activity related activities of daily living (ADLs).
- The mobility subscale of a risk assessment tool.
- Descriptors of activity (such as bed/chairfast) or immobility.
- Factors that affect mobility.
- General ADLs.
- The friction and/or shear subscale of a risk assessment tool.
- The activity subscale of risk assessment tool.
- Interface pressure.


Table 1: Summary of evidence for measures of mobility/activity as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Mobility/activity related activities of daily living (ADLs)	55.5% (5 of 9 studies)	Studies in which risk factors were significant in the model ^{24, 46, 51, 53, 65} Studies in which risk factors were not significant in the model ^{20, 29, 49, 75}
Mobility subscale of a risk assessment tool	52.9% (9 of 17 studies)	Studies in which risk factors were significant in the model ^{8, 18, 20, 30, 31, 38, 39, 48, 61} Studies in which risk factors were not significant in the model ^{12, 22, 35, 47, 52, 59, 60, 69}
Descriptors of activity (e.g., bed/chairfast, immobile)	50.0% (7 of 14 studies)	Studies in which risk factors were significant in the model ^{17, 21, 41, 44, 45, 54, 65} Studies in which risk factors were not significant in the model ^{13, 19, 20, 27, 29, 64, 75}
Factors affecting mobility	50% (12 of 24 studies)	Studies in which risk factors were significant in the model ^{8, 16, 20, 23, 49, 52, 60, 63, 64, 67, 70, 74} Studies in which risk factors were not significant in the model ^{13, 21, 27, 28, 32, 53, 59, 66, 68, 71, 73, 75}
General ADLs	50.0% (3 of 6 studies)	Studies in which risk factors were significant in the model ^{19, 20, 65} Studies in which risk factors were not significant in the model ^{21, 24, 65}
Friction and/or shear subscale of a risk assessment tool	33.3% (5 of 15 studies)	Studies in which risk factors were significant in the model ^{8, 27, 35, 48, 59} Studies in which risk factors were not significant in the model ^{18, 20, 22, 28, 38, 39, 60, 61, 68, 69}
Activity subscale of a risk assessment tool	16.6%(3 of 18 studies)	Studies in which risk factors were significant in the model ^{8, 31, 69} Studies in which risk factors were not significant in the model ^{18, 20, 22, 28, 30, 35, 38, 39, 43, 47, 48, 52, 59-61}
Interface pressures	66.6% (2 of 3 studies)	Studies in which risk factors were significant in the model ^{57, 58} Studies in which risk factors were not significant in the model ⁶⁶

1.3. Complete a comprehensive risk assessment for bedfast and/or chairfast individuals to guide preventive interventions. (Strength of Evidence = C; Strength of Recommendation = )

This statement is based on expert opinion. Mobility and activity limitations can be considered a **necessary condition** for pressure ulcer development. In the absence of these conditions, other risk factors should not result in a pressure ulcer. However, pressure ulcers are multi-causal and it is important to identify any other potential contributing factors in immobile individuals in order to implement a comprehensive prevention plan.

Skin status

1.4. Consider individuals with a Category/Stage I pressure ulcer to be at risk of progression or new Category/Stage II and greater pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = )

- 1.5. Consider individuals with an existing pressure ulcer (any Category/Stage) to be at risk of additional pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**
- 1.6. Consider the general status of skin on pressure ulcer risk. (Strength of Evidence = B; Strength of Recommendation = 👍)**

These statements are based upon high quality epidemiological evidence (see *Table 2*). The literature identifies that skin/pressure ulcer status emerges consistently in multivariable modeling and demonstrates a strong statistical association with the development of new pressure ulcers.

Epidemiological studies utilizing multivariable modeling consistently identify the presence of non-blanching erythema (a Category/Stage I pressure ulcer) and alterations to intact skin as increasing the probability of pressure ulcer development (see *Table 2*)^{2, 12} (Level 2 and 4 studies). The presence of an existing pressure ulcer of any Category/Stage emerges less consistently as a significant predictor of new pressure ulcer development^{2, 63, 65, 75} (Level 2 and 4 studies).

In terms of the underlying conceptual framework, skin status is associated with the susceptibility and tolerance of the skin, indicating that physiology and repair and transport properties of the skin have been disrupted.

Table 2: Summary of evidence for measures of skin status as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Existing Category/Stage I pressure ulcer	100% (4 of 4 studies)	Studies in which risk factors were significant in the model ^{17, 42, 43, 50}
General skin status	90.9% (10 of 11 studies)	Studies in which risk factors were significant in the model ^{9, 12, 17, 26, 28, 40, 43, 47, 51, 54} Studies in which risk factors were not significant in the model ²³
Existing pressure ulcer of any Category/Stage	37.5% (3 of 8 studies)	Studies in which risk factors were significant in the model ^{19, 28, 65} Studies in which risk factors were not significant in the model ^{15, 43, 59, 63, 75}
Previous pressure ulcers	25.0% (1 of 4 studies)	Studies in which risk factors were significant in the model ⁶⁸ Studies in which risk factors were not significant in the model ^{17, 35, 64}

- 2. Consider the impact of the following factors on an individual's risk of pressure ulcer development:**
- perfusion and oxygenation;
 - poor nutritional status; and
 - increased skin moisture. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based upon primarily moderate and low quality epidemiological evidence. The literature identifies that these three risk factors emerge in epidemiological studies on pressure ulcer risk, demonstrating a moderate association with the development of new pressure ulcers.

Perfusion and Oxygenation

Epidemiological studies consistently identify alterations to tissue perfusion and oxygenation as increasing the probability of pressure ulcer development (Level 2 and 4 studies). Results from a number of epidemiological studies that employed multivariable analyses indicate that various factors affecting tissue perfusion and oxygenation increase the risk of pressure ulcer development (see *Table 3*).

However, translation into practice, (i.e., how tissue perfusion and oxygenation can be assessed) is complicated by the wide range of descriptors and direct and indirect measures utilized by researchers. Examples include diabetes; cerebrovascular accident (CVA); renal disease; cardiac disease; vascular disease; peripheral vascular disease (PVD); cardiovascular instability/norepinephrine use; pulse pressure; ‘skin circulation’; cyanosis, popliteal and posterior tibial pulses; hematocrit; low diastolic blood pressure; decreased ankle brachial index; hypotension; high systolic blood pressure; hypertension; inotrope administration; cigarette smoking and oxygen use.^{2, 66, 69-71, 73, 74}

In terms of the underlying conceptual framework (see *Figure 1*), perfusion and oxygenation factors are associated with the susceptibility and tolerance of the skin, with consideration given to the potential impact upon individual physiology and repair; and transport and thermal properties.

Table 3: Summary of evidence for measures of perfusion and circulation as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Vascular disease	66.6% (4 of 6 studies)	Studies in which risk factors were significant in the model ^{21, 32, 41, 60} Studies in which risk factors were not significant in the model ^{29, 59}
Alterations to blood pressure (low or high)	61.5% (8 of 13 studies)	Studies in which risk factors were significant in the model ^{10, 23, 25, 42, 47, 60, 66, 70} Studies in which risk factors were not significant in the model ^{13, 29, 39, 45, 57}
Diabetes	50.0% (7 of 14 studies)	Studies in which risk factors were significant in the model ^{14, 24, 43, 46, 49, 73, 74} Studies in which risk factors were not significant in the model ^{15, 21, 26, 29, 32, 35, 60}
Circulation	50% (5 of 10 studies)	Studies in which risk factors were significant in the model ^{26, 44, 45, 69, 71} Studies in which risk factors were not significant in the model ^{28, 32, 59, 66, 70}
Smoking	40% (2 of 5 studies)	Studies in which risk factors were significant in the model ^{57, 58} Non-significant studies ^{29, 32, 68}
Edema	20% (1 of 5 studies)	Studies in which risk factors were significant in the model ²⁶ Studies in which risk factors were not significant in the model ^{20, 29, 41, 73}

Nutrition Indicators

A number of Level 2 and 4 studies have identified that nutritional deficits increase the probability of pressure ulcer development (see *Table 4*).^{2, 12, 72, 74, 75} Indicators of nutritional deficits reported in these studies and considered in the multivariable model included descriptors, scales and measures as follows:

- Study specific descriptors of food intake.
- Presence of malnutrition (e.g., diagnosis of malnourishment recorded in medical record).
- Arm measurements.
- Nutrition assessment scales.
- Low weight and weight loss.
- Low body mass index (BMI).
- Other measures of nutritional status (e.g., nutrition screening resulting in a dietitian referral).

None of the studies included in the multivariable model specifically investigated elevated weight or BMI as a potential risk factor for pressure ulcers. The potential relationship between obesity and pressure ulcer occurrence is discussed in the guideline section *Special Populations: Bariatric (Obese) Individuals*.

In terms of the underlying conceptual framework (see *Figure 1*), nutritional deficits are associated with, and may impact upon all four components of the susceptibility and tolerance of the skin, including mechanical properties of the tissue; the geometry (morphology) of the tissues; physiology and repair; and transport and thermal properties.

Table 4: Summary of evidence for measures of nutritional status as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Study specific descriptors of food intake	57.1% (4 of 7 studies)	Studies in which risk factors were significant in the model ^{10, 21, 24, 31} Studies in which risk factors were not significant in the model ^{20, 27, 28}
Malnutrition	33.3% (1 of 3 studies)	Studies in which risk factors were significant in the model ⁵⁰ Studies in which risk factors were not significant in the model ^{29, 55}
Arm measurements	33.3% (1 of 3 studies)	Significant studies ⁴⁷ Studies in which risk factors were not significant in the model ^{17, 56}
Low weight and weight loss	28.6% (4 of 14 studies)	Studies in which risk factors were significant in the model ^{17, 25, 39, 42} Studies in which risk factors were not significant in the model ^{10, 23, 26, 37, 38, 45, 61, 62, 71, 75}
Low body mass index (BMI)	28.6% (4 of 14 studies)	Studies in which risk factors were significant in the model ^{13, 14, 72, 74} Studies in which risk factors were not significant in the model ^{24, 26, 28, 32, 39, 56, 60, 64, 66, 68}
Nutrition assessment scales	6.6% (1 of 15 studies)	Studies in which risk factors were significant in the model ⁵⁶ Studies in which risk factors were not significant in the model ^{18, 22, 28, 30, 35, 38, 39, 43, 47, 48, 59-61}
Other measures of nutrition status	33.3% (3 of 9 studies)	Studies in which risk factors were significant in the model ^{12, 72, 75} Studies in which risk factors were not significant in the model ^{26, 37, 61, 62, 64, 65}

Skin Moisture

General measures of skin moisture, including urinary and fecal incontinence, emerge inconsistently in epidemiological studies as factors which increase the probability of pressure ulcer development (Levels 2 and 4 studies). Indicators of skin moisture utilized in the literature include descriptors, scales and measures as follows (see *Table 5*):^{2, 8, 65}


- Dual incontinence.
- Skin moisture.
- The moisture subscale of a risk assessment tool.
- Fecal incontinence.
- Urinary catheter insitu.
- Urinary incontinence.
- Incontinence (type unspecified).

It should be considered that a certain level of skin hydration is necessary to ensure proper skin function and resistance. The factors listed above refer to excess moisture. In terms of the underlying conceptual framework (see *Figure 1*) excess moisture impacts the susceptibility and tolerance of the skin by affecting the barrier and mechanical properties of the tissue; and physiology and repair.

Table 5: Summary of evidence for measures of skin moisture as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Dual incontinence	60.0% (3 of 5 studies)	Studies in which risk factors were significant in the model ^{20, 46, 60} Studies in which risk factors were not significant in the model ^{19, 59}
Skin moisture	60.0% (3 of 5 studies)	Studies in which risk factors were significant in the model ^{20, 26, 57} Studies in which risk factors were not significant in the model ^{27, 35}
Moisture subscale of a risk assessment tool	35.7% (5 of 14 studies)	Studies in which risk factors were significant in the model ^{8, 18, 35, 52, 59} Studies in which risk factors were not significant in the model ^{20, 22, 28, 30, 38, 48, 60, 61, 68}
Fecal incontinence	25.0% (3 of 12 studies)	Studies in which risk factors were significant in the model ^{24, 40, 65} Studies in which risk factors were not significant in the model ^{13, 17, 23, 29, 35, 45, 50, 57, 64}
Urinary catheter insitu	25.0% (1 of 4 studies)	Studies in which risk factors were significant in the model ⁵⁰ Studies in which risk factors were not significant in the model ^{21, 26, 65}
Urinary incontinence	12.5% (1 of 8 studies)	Studies in which risk factors were significant in the model ⁴⁷ Studies in which risk factors were not significant in the model ^{19, 20, 24, 29, 35, 52, 65}
Incontinence (type unspecified)	100% (1 of 1 study)	Studies in which risk factors were significant in the model ⁴⁷

3. Consider the potential impact of the following factors on an individual’s risk of pressure ulcer development:

- **increased body temperature;**
- **advanced age;**
- **sensory perception;**
- **hematological measures and;**
- **general health status (Strength of Evidence = C; Strength of Recommendation = )**

This statement is based upon high and medium quality epidemiological evidence. The literature identifies that these four risk factors emerge inconsistently in epidemiological studies on pressure ulcer risk, demonstrating a weak association with the development of pressure ulcers. Advanced age, sensory perception and health status are likely confounding factors of characteristics demonstrated to be strong risk factors of pressure ulcer development, particularly immobility.

Body Temperature

A systematic review by Coleman et al. (2013)² identified eight studies (see *Table 6*) that included body temperature in multivariable modeling and, of these, three studies reported an independent statistical association between elevated body temperature and pressure ulcer development, one reported an association but not the direction of the relationship and in three studies body temperature did not emerge in multivariable modeling (Level 2 and 4 studies). No new studies were found in the updated review. This may be an aspect that is considered in risk assessment, but it is an area which requires confirmatory research.

In terms of the underlying conceptual framework, body temperature may impact upon the susceptibility and tolerance of the skin by affecting physiology and repair; and transport and thermal properties.

Table 6: Summary of evidence for measures of body temperature as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Body temperature	62.5% (5 of 8 studies)	Studies in which risk factors were significant in the model ^{10, 41, 51, 57, 58} Studies in which risk factors were not significant in the model ^{30, 32, 60}

Advanced Age

Early prevalence surveys established that pressure ulcers are generally associated with advanced age, although it is recognized that pressure ulcers do affect individuals of all ages, including infants and neonates in whom other risk factors are present. A large number of studies (n = 40) have included age within multivariable modelling. Increasing age emerges as an independent risk factor in only 15 (37.5%) studies^{2, 71, 73, 75} (Level 2 and 4 studies) (see *Table 7*). It is suggested that age is a confounding factor and a general indicator of likely deficits in the main areas of risk including mobility/activity; skin status; perfusion and oxygenation; nutrition; and skin moisture. Therefore, in terms of the underlying conceptual framework (see *Figure 1*), at an individual level age may impact upon both the mechanical boundary conditions and all four components of susceptibility and tolerance of the skin: mechanical properties of the tissue; the geometry (morphology) of the tissue; physiology and repair; and transport and thermal properties.

Table 7: Summary of evidence for measures of increasing age as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Increasing age	37.5% (15 of 40 studies)	Studies in which risk factors were significant in the model ^{10, 11, 14, 34-36, 39, 43, 46, 48, 56, 60, 71, 73, 75} Studies in which risk factors were not significant in the model ^{12, 13, 17, 19-21, 24-28, 32, 33, 37, 38, 42, 45, 59, 61-64, 67, 68, 74}

Sensory Perception

A systematic review by Coleman et al. (2013)² identified nine studies which included the Braden sensory perception subscale in multivariable modeling and a further three studies have been identified in this update.^{8, 12, 69} Sensory perception emerges in only four (33.3%) of the 12 studies identified, despite widespread clinical recognition that this is an important risk factor (Level 2 and 4 studies). It is likely that in statistical modeling other confounding factors related to sensory deficits, including factors associated with loss of sensation (e.g., diabetic neuropathy and spinal cord injury) and lack of response (e.g., mental capacity or acuity of illness) are dominant.

In terms of the underlying conceptual framework, sensory perception impacts upon the mechanical boundary conditions.

Table 8: Summary of evidence for measures of sensory perception as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Sensory perception subscale of the Braden Scale	33.3% (4 of 12 studies)	Studies in which risk factors were significant in the model ^{8, 12, 28, 35} Studies in which risk factors were not significant in the model ^{18, 22, 38, 48, 59-61, 69}

Hematological Measures

A number of Level 2 and 4 studies^{2, 64} have reported a statistical association between abnormal hematological measures and pressure ulcer development, including alterations to urea and electrolytes (e.g., creatinine above 1 mg/dl), elevated C-reactive protein, lymphopenia, low albumin, and low hemoglobin. Direct interpretation and application to practice is complicated by the diversity of causes for abnormality in hematological measures ranging from severe malnutrition to blood loss during surgery and the impact upon the tolerance of the tissues may be multi-factorial.

In terms of the underlying conceptual framework (see *Figure 1*), abnormal hematological measures may impact upon the susceptibility and tolerance of the skin by affecting physiology and repair; and transport and thermal properties.

Table 9: Summary of evidence for hematological measures as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Lymphopenia	100% (2 of 2 studies)	Studies in which risk factors were significant in the model ^{17, 47}
Albumin	58.3% (7 of 12 studies)	Significant studies ^{16, 31, 36, 40, 43, 50, 56} Studies in which risk factors were not significant in the model ^{10, 38, 39, 52, 64}
Hemoglobin (Hb)	54.5% (6 of 11 studies)	Studies in which risk factors were significant in the model ^{15, 20, 36, 43, 45, 47} Studies in which risk factors were not significant in the model ^{32, 34, 42, 44, 56}
Urea and Electrolytes (U&Es)	50% (2 of 4 studies)	Studies in which risk factors were significant in the model ^{52, 56} Studies in which risk factors were not significant in the model ^{21, 44}
Protein (C-reactive protein)	33.3% (1 of 3 studies)	Significant studies ³⁶ Studies in which risk factors were not significant in the model ^{40, 53}
Other hematological measures	100% (1 of 1 studies)	Studies in which risk factors were significant in the model ³⁶

General Health Status

A number of epidemiological studies have used measures indicating general and mental health status and these have emerged inconsistently in multivariable modeling as predictive of pressure ulcer development (Level 2 and 4 studies). Examples (see *Table 10*) include number of activities of daily living (ADL) dependencies; do-not-resuscitate (DNR) status; mechanical ventilation illness severity scores, including the APACHE II, Ramsey, and acquired immune deficiency syndrome (AIDS) severity and performance indices; confusion/mental status; acute (versus elective) admission; surgical treatment; various medication treatments; and length of stay.^{2, 8, 63-66, 69, 71, 72, 74, 75}

It is suggested that general health status is a confounding factor and a general indicator of likely deficits in the main areas of risk including mobility/activity, skin status and perfusion, nutrition and skin moisture. Therefore, in terms of the underlying conceptual framework, at an individual level, general health status impacts upon both the mechanical boundary conditions and all four components of the susceptibility and tolerance of the skin.

Table 10: Summary of evidence for measures of mental and general health status as a risk factor for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
General health status		
American Society of Anesthesiologists (ASA) score	50% (1 of 2 studies)	Studies in which risk factors were significant in the model ⁴⁹ Studies in which risk factors were not significant in the model ²⁹
Chronic wounds	50% (1 of 2 studies)	Studies in which risk factors were significant in the model ⁴³ Studies in which risk factors were not significant in the model ⁴²
Acute Physiology and Chronic Health Evaluation (APACHE II) score	40% (2 of 5 studies)	Studies in which risk factors were significant in the model ^{62, 63} Studies in which risk factors were not significant in the model ^{26, 37, 41}
Medication	38.5% (5 of 13 studies)	Studies in which risk factors were significant in the model ^{15, 20, 41, 72, 74} Studies in which risk factors were not significant in the model ^{24, 26, 29, 45, 55, 60, 62, 68}
Norton score measures	0% (0 of 3 studies)	Non-significant studies ^{28, 30, 48}
Other factors	41.7% (15 of 36 studies)	Studies in which risk factors were significant in the model ^{8, 14, 39-41, 43, 49, 50, 62, 64, 66, 69, 71, 74, 75} Studies in which risk factors were not significant in the model ^{9, 12, 13, 20, 24, 26-29, 32, 35, 37, 42, 44, 52, 55, 56, 61, 65, 68, 73}
Mental health status		
Mental status study specific measures	22.2% (2 of 9 studies)	Studies in which risk factors were significant in the model ^{50, 65} Non-significant studies ^{19, 20, 24, 29, 35, 47, 53}
Mental status subscale of a risk assessment tool	20% (1 of 5 studies)	Studies in which risk factors were significant in the model ⁴⁸ Studies in which risk factors were not significant in the model ^{28-30, 47}
Mini Mental State Exam (MMSE)	0.0% (0 of 1 studies)	Studies in which risk factors were not significant in the model ⁶⁴

Other Potential Risk Factors for Pressure Ulcers

A number of risk factor studies (see *Table 11*) have explored the relationship between race and gender and pressure ulcer development, but results from different studies are contradictory and inconclusive. Whilst prevalence data indicates the rate of pressure ulcers is higher in people with darkly pigmented skin,⁷⁶⁻⁸¹ only one epidemiological study demonstrated an increased risk in individuals with darkly pigmented skin. It is suggested that the observed increased prevalence rate may be due to delayed detection rather than to a true increase in risk (see the *Classification of Pressure Ulcers* and *Assessment of Pressure Ulcers and Monitoring of Healing* sections of the guideline for further discussion).

Table 11: Summary of evidence for demographic characteristics as risk factors for pressure ulcer development

Risk factor variables	Percent studies significant in multivariable model	Risk factor significant and non-significant in multivariable model
Race		
1 study identified increased risk for Caucasian skin, 1 study identified increased risk for dark skin tones	40% (2 of 5 studies)	Studies in which risk factors were significant in the model ^{11, 19} Studies in which risk factors were not significant in the model ^{9, 12, 24}
Gender		
4 studies identified increased risk for males, 2 studies identified increased risk for females	30% (6 of 20 studies)	Significant studies ^{20, 26, 36, 44, 67, 68} Studies in which risk factors were not significant in the model ^{11-13, 19, 23, 24, 29, 33, 37, 39, 56, 63, 64, 74}

Risk Assessment Tools

Most risk assessment tools incorporate many of the risk factors discussed above (e.g., activity, mobility, nutrition, moisture, sensory perception, friction and shear, and general health condition). However, the volume of epidemiological research has increased considerably in recent years, providing for a better understanding of the risk factors important in the development of pressure ulcers, and risk assessment tools do not incorporate these advances in knowledge. If risk assessment tools are selected as a structured approach for risk assessment, additional factors (e.g., perfusion, skin status and other relevant risks) should be considered as part of a comprehensive risk assessment. Table 12 compares the risk factors supported by current epidemiological studies with the risk factors measured by the three most commonly used risk assessment tools, identifying gaps for each tool. Regardless of how the risk assessment is structured, **clinical judgment is essential**.

Table 12: Comparison of Risk Factors Identified in Both Epidemiological Studies and Commonly Used Risk Assessment Tools

Note: An asterisk (*) indicates that the actual subscale was significant in multivariable modeling in one or more epidemiological study identified. Lack of an asterisk may indicate non-significance in multivariable modeling, but may also indicate that the subscale was not entered in any multivariable modeling studies. “Not included” indicates the risk factor is not included on the risk assessment tool, identifying a gap that health professionals should consider during a comprehensive risk assessment.

Risk Factors from Epidemiological Studies	Braden Scale	Norton Scale	Waterlow Score
Key Risk Factors			
Activity and mobility limitations	Mobility* Activity* Friction-shear*	Mobility* Activity*	Mobility
Skin status	Not included	Not included	Skin type <i>(in visual areas of risk, a partial measurement of skin status)</i>
Consider the Impact of These Risk Factors			
Perfusion and oxygenation	Not included	Not included	Special Risk <i>(partial measurement of perfusion)</i>
Poor nutritional status	Nutrition	Food intake Fluid intake <i>(in a modified scale)</i>	Appetite Build (weight for height)
Increased skin moisture	Moisture*	Incontinence	Continence

Risk Factors from Epidemiological Studies	Braden Scale	Norton Scale	Waterlow Score
Consider the Potential Impact of These Risk Factors			
Increased body temperature	Not included	Not included	Not included
Advanced age	Not included	Not included	Gender/Age
Sensory perception	Sensory Perception*	Not included	Neurological Deficit
Hematological measures	Not included	Not included	Not included
General health status	Not included	Physical condition Mental condition*	Major Surgery/Trauma Medications

1. **Recognize additional risk factors and use clinical judgment when using a risk assessment tool.** (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Caution: Do not rely on the results of a risk assessment tool alone when assessing an individual's pressure ulcer risk.

This statement is based upon expert opinion. A risk assessment tool offers a structured approach to assessment, but does not replace a comprehensive assessment conducted by an appropriately qualified health professional using a structured approach to clinical judgment. The majority of the currently available risk assessment tools were developed on the basis of literature review, expert opinion, and/or adaptation of an existing scale. The three most commonly used scales – the Norton Scale© (1962),⁸² Waterlow Score© (1985),⁸³ and the Braden Scale for Predicting Pressure Sore Risk© (1987)⁸⁴ – were developed more than twenty years ago without the insight from more recent epidemiological studies.

Risk assessment tools do not necessarily include assessment of all key factors that can increase the risk of pressure ulcer development. Specifically, most risk assessment tools do not include an assessment of tissue perfusion or skin status. As presented under *Risk Factors for Pressure Ulcers* (see above), epidemiological studies identify these factors as strong indicators of pressure ulcer risk. It is important to consider tissue perfusion and skin status in conjunction with an assessment conducted with a formalized risk assessment tool.

Additionally, most risk assessment tools use a simple ordinal system to score risk. They are limited in their ability to assess any potential differences in the contribution or importance of one risk factor versus another, or to assess the cumulative effect of two or more risk factors. In an attempt to create a simple screening tool for clinical use, the complex interplay of individual and environmental factors has been reduced to a simple score. Therefore, clinical judgment must be exercised to interpret these scores with consideration of the impact of other risk factors and within the context of often-complex individual and clinical factors.

Risk Assessment Tools versus Clinical Judgment

A large number of risk assessment tools have been developed to provide a structured approach for risk assessment in practice, yet the results of studies comparing risk assessment tools to clinical judgment are mixed. Risk assessment tools provide some advantages over clinical judgment alone. For example, they provide:

- a practical framework;
- operational definitions of risk factors that have clinical utility and can be reliably measured;
- clinical reminders (especially for novice nurses); and
- a minimum auditable standard.

A meta-analysis conducted by García-Fernández et al. (2014)⁸⁵ reported relatively poor pooled predictive capacity indicators for clinical judgment as measured by relative risk (RR = 1.95; 95% confidence interval [CI] 0.94 to 4.04) when compared to the Braden Scale (RR = 4.26; 95% CI 3.27 to 5.55), Norton Scale (RR = 3.69; 95% CI 2.64 to 5.16), Waterlow Score (RR = 2.66, 95% CI 1.76 to 4.01) and modified Cubbin-Jackson Scale for critically ill individuals (RR = 3.16; 95% CI 1.49 to 6.71). When 1.0 (null value, i.e. equal odds) is included in the confidence interval (see clinical judgment results), results are considered less than conclusive.

Moore et al. (2014)⁸⁶ conducted a systematic review to determine if using structured systematic pressure ulcer risk assessment tools reduced the incidence of pressure ulcers. Finding only two studies meeting their inclusion criteria,^{75, 87} they concluded that there was no evidence from randomized controlled trials (RCTs) to suggest structured pressure ulcer risk assessment reduces the incidence of pressure ulcers.


One of these trials was a large, blinded randomized trial conducted by Webster et al. (2011)⁷⁵ that compared use of a Waterlow Score (n = 410), the Ramstadius risk screening tool (n = 411) and risk assessment based on the nurse's clinical judgment (n = 410) for reducing pressure ulcer occurrence in participants located in medical and oncology wards in Australia. After the four day follow up period, facility-acquired pressure ulcer rates were not significantly different between those assessed with the Waterlow Score versus clinical judgment (7.5% versus 6.8%, risk ratio = 1.10, 95% CI 0.68 to 1.81, p = 0.69) or between those assessed with the Ramstadius risk screening tool versus clinical judgment (5.4% versus 6.8%, risk ratio = 0.79, 95% CI 0.46 to 1.35, p = 0.38). The difference in pressure ulcer rates between the two groups assessed with risk assessment tools was also not significant (p = 0.18) (Level 2 study).

In the second of the trials reported in the systematic review by Moore et al. (2014)⁸⁶, Saleh et al. (2009)⁸⁷ conducted a cluster randomized trial in a military hospital in Saudi Arabia. Participants were considered to be at risk of pressure ulcers (Braden Scale score ≤ 18). The trial, which had three groups, compared the use of the Braden risk assessment tool (group A; n = 74); nurse education on the Braden Scale but risk assessment conducted using clinical judgment alone (group B; n = 76) and risk assessment using clinical judgment without accompanying education (group C; n = 74). After eight weeks, there was no statistically significant difference in pressure ulcer incidence between group A and group B (16 versus 17 pressure ulcers, risk ratio = 0.97; 95% CI 0.53 to 1.77, p = 0.91). There was also no statistically significant difference in pressure ulcer incidence between group A and group C (16 pressure ulcers in each group, risk ratio = 1.43; 95% CI 0.77 to 2.68, p = 0.26). The trial was considered to be at high risk of bias (Level 2 study).

An additional clinical trial designed primarily to assess the effectiveness of different repositioning regimens that did not meet inclusion criteria for the review conducted by Moore et al. (2014)⁸⁶ reported on different strategies to assess pressure ulcer risk. Participants (n = 1,772) were assessed using the Norton Scale, the Braden Scale and by nurses using their own clinical judgment⁸⁸ after being randomly allocated to different repositioning regimen groups. Sensitivity of clinical judgment was 25% to 28% lower than assessment using the risk assessment tools and specificity was 20% to 30% higher. Fewer individuals who developed a pressure ulcer were identified as being at risk when clinical judgment was used, but of those individuals identified at risk, more actually developed a pressure ulcer. The two risk assessment tools were essentially equivalent in predicting development of pressure ulcers. Education background and clinical experience of the nurses participating in the study were not reported (Level 5 study).

There are limitations to the current research that prevent a clear comparison between risk assessment tools and clinical judgment alone.⁸⁹ In the majority of studies investigating risk assessment strategies, preventive interventions are initiated on the basis of the risk assessment. These interventions will impact upon pressure ulcer incidence, confounding the evaluation of the risk assessment strategy. Defloor et al. (2005)⁸⁸ highlight that development of a pressure ulcer in an individual assessed as being at risk is primarily an indication that preventive management was insufficient, rather than an indication that the

risk assessment strategy was reliable. In the studies conducted by Saleh et al. (2009)⁸⁷ and Defloor et al. (2005)⁸⁸, there was non-equivalent use of pressure ulcer prevention strategies, in particular the types of support surfaces used, between individuals identified at risk and not at risk and this confounded the findings. In the higher quality study conducted by Webster et al. (2011)⁷⁵, non-significant differences in pressure ulcer prevention interventions initiated following the risk assessment is reported.

2. When using a risk assessment tool, select a tool that is appropriate to the population, is valid and is reliable. (Strength of Evidence = C; Strength of Recommendation = )

This statement is based upon expert opinion. A review of the evidence on reliability and validity for the most commonly used pressure ulcer risk assessment tools is provided below.

Reliability

Reliability refers to the consistency and the ability of scores to differentiate among subjects. Reliability is widely regarded as a necessary condition for validity. There are a large number of studies that specifically address the interrater and intrarater reliability of risk assessment tools and reports of early tool development usually contain some measure of reliability. There are generally high levels of reliability in terms of total scores for the Modified Norton Scale (intraclass correlation coefficient [ICC] = 0.821, 95% CI 0.715 to 0.926)⁹⁰ and Braden Scale (ICC range = 0.72 to 0.95).⁹¹⁻⁹⁵ Interrater reliability for the Waterlow Score was reported as 1.0 in one study⁷⁵ and as 0.36 (95% CI 0.09 to 0.63) in a second study.⁹¹ Interrater reliability for subscale scores varied depending on the subscale and the clarity of the operational definition.⁹⁰⁻⁹⁵ Ongoing education and competency testing for health professionals administering risk assessment tools are important to support reliability.

Validity

Validity refers to the degree to which a tool measures what it claims to measure. Of the many types of validity (e.g., content, construct and criterion), 'predictive validity' has received the most attention in relation to risk assessment tools. Rather than focus on the degree to which these tools accurately measure risk factors such as mobility, activity and skin moisture, we have focused on the degree to which they predict a future event (i.e., pressure ulcer development).

A major problem identified in the literature⁸⁸ in establishing predictive validity of risk assessment tools is that preventive interventions are initiated in the majority of studies, and these will impact upon the performance of the tool. Studies of predictive validity are prognostic (estimating the likelihood of a future problem) rather than diagnostic (identifying an existing problem). Despite these constraints, most studies of predictive validity report some statistical estimates of likelihood associated with each prognostic method. These include sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), area under receiver operator curves (as an indication of the best balance between sensitivity and specificity; area under receiving operator characteristic [AUROC]) and relative risk. Although these measures are imperfect, they provide some insight into the predictive validity of risk assessment tools, especially when considered in light of the intervening preventive strategies.

Table 13 summarizes the estimates for the three most frequently studied risk assessment tools. Data for this table were abstracted from a systematic review that met criteria for guideline inclusion as identified in the *Methodology* section of the guideline.³ One relevant article was published after the inclusion date (July 2012) for review by Chou et al. (2013)³ but before the end of the guideline review period (July 2013). In this study,⁹⁶ predictive validity was determined for Norton, Braden and Waterlow Scores for 100 surgical participants in New Delhi, India. Specificity for the Norton and Braden scales fell well within the range of those summarized by Chou et al. (2013)³. Predictive validity of the Waterlow Score was higher than that reported by Chou et al. (2013)³. At a cutoff score of 10, sensitivity was 95.65%, and specificity was 74.02%.⁹⁶

Table 13: Psychometric qualities of major risk assessment tools based on data from Chou et al. (2013)³

Note: The Chou et al. (2013)³ analysis did not provide estimates of relative risk. These were taken from a meta-analysis conducted by García-Fernández et al. (2014)⁸⁵

Scales (cut-off)	Sensitivity Median (range)	Specificity Median (range)	PLR	NLR	AUROC Median (range)	Relative Risk (95% CI)
Braden (≤18)	0.74 ^a (0.33 to 1)	0.68 ^a (0.34 to 0.86)	2.31 ^a	0.38 ^a	0.77 ^b (0.55 to 0.88)	4.26 ^f (3.27 to 5.55)
Norton (≤14)	0.75 ^c (0 to 0.89)	0.68 ^c (0.59 to 0.95)	2.34 ^c	0.37 ^c	0.74 ^c (0.56 to 0.75)	3.69 ^g (2.64 to 5.16)
Waterlow (≥10)	1.00, 0.88 ^d	0.13, 0.29 ^d	1.15, 1.24 ^d	0.0, 0.41 ^d	0.61 ^e (0.54 to 0.66)	2.66 ^h (1.76 to 4.01)
	^a 16 studies, n=5,462 ^d 2 studies, n=419 ^g 15 studies, n=4,935	^b 7 studies, n=4,811 ^e 4 studies, n=2,559 ^h 12 studies, 2,408		^c 5 studies, n=2,809 ^f 31 studies, n=7,137		

Other risk assessment tools have received minimal psychometric testing. Those noted in publications over the five year review period for this guideline revision include the Suriadi and Sanada Scale,⁵⁸ Risk Assessment Pressure Sore Scale,⁹⁷ The Modified Norton Scale,⁹⁰ Ramstadius,⁷⁵ and Cubbin-Jackson Scales.^{98, 99} The guideline sections *Special Populations: Pediatric Individuals* and *Special Populations: Individuals in Palliative Care* discuss population specific risk assessment tools.

Comparison of Risk Tools

The systematic comparative effectiveness review completed by Chou et al. (2013)³ attempted to answer the question: “How do various risk assessment tools compare with one another in their ability to predict the incidence of pressure ulcers?” The reviewers identified 14 studies that directly compared two or more risk assessment tools in the same population. Six studies^{23, 28, 48, 100-102} reported that the AUROCs within each study were comparable. AUROC’s ranged between 0.66 and 0.90 with the exception of one study¹⁰⁰ in which AUROCs ranged between 0.55 and 0.61 which is roughly equivalent to chance (0.50). An AUROC offers the best balance between sensitivity and specificity.

The eight studies^{23, 28, 100, 101, 103-105} examining sensitivity and specificity reported very similar findings for comparisons of tools within the same population(s). Sensitivity and specificity vary by the cut-off score used for the tool. Most cutoff scores are selected to optimize sensitivity and specificity; however, clinical judgment is important when considering trade-offs between sensitivity and specificity. A higher sensitivity (but lower specificity) will facilitate identification of more true-positive at-risk individuals, but will also require greater resource utilization as both true-positive and false-positive individuals receive preventive interventions. A higher specificity (but lower sensitivity) will facilitate more efficient utilization of resources as those not developing pressure ulcers are more clearly identified during risk assessment; however, some individuals who may have benefited from prevention will not be identified.

The systematic review conducted by Chou et al. (2013)³ also examined whether the predictive validity of risk assessment tools differ across clinical settings or according to individual patient characteristics. Few studies addressed these issues and results were inconclusive.

In the midst of these discussions, one must remember that ‘prediction is not destiny’. The outcome for an at-risk individual can often be altered by carefully selected and consistently implemented, risk-based prevention strategies. The best method for identifying risk has not been determined. Available evidence is summarized to guide clinical decision making.

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SKIN AND TISSUE ASSESSMENT

Introduction

Skin and tissue assessment is important in pressure ulcer prevention, classification, diagnosis, and treatment. The condition of skin and underlying tissue can serve as an indicator of early signs of pressure damage,¹ therefore routine skin and tissue assessments provide an opportunity for early identification and treatment of skin alterations, especially pressure ulcers. Refer to the *Medical Device Related Pressure Ulcers* section of the guideline for discussion of assessment of mucus membranes and other pressure ulcers associated with medical devices.

Various skin alterations appear to be associated with pressure ulcer development. Alterations in skin status and function such as dryness, thinning or inflammation weakens the skin barrier and increases the susceptibility to a wide range of skin problems, including superficial pressure ulcers. Advanced age, medications (e.g., steroids) or chronic disease (e.g., diabetes mellitus) are all associated with skin impairments. Excess moisture on the skin surface (e.g., due to increased perspiration or incontinence) also increases skin vulnerability to damage related to skin maceration or pressure and shear forces.² Especially in pressure ulcer risk estimation, the presence of nonblanchable erythema is a risk factor for Category/Stage II pressure ulcers.³

Skin Assessment Policy Recommendations

- 1. Ensure that a complete skin assessment is part of the risk assessment screening policy in place in all health care settings. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Each health care setting should have a policy in place outlining recommendations for a structured approach to skin assessment relevant to the setting that include anatomical locations to be targeted and the timing of assessment and reassessment. It should make clear recommendations for documenting skin assessment and communicating information to the wider health care team.

- 2. Educate health professionals on how to undertake a comprehensive skin assessment that includes the techniques for identifying blanching response, localized heat, edema, and induration. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

These assessment techniques should be used in assessing the skin of all individuals. However, there is evidence that Category/Stage I pressure ulcers are under-detected in individuals with darkly pigmented skin because areas of redness are not easily identified. In a study of 1,938 residents of 59 nursing homes, Baumgarten et al. (2004)⁴ reported a significantly higher rate of Category/Stage II to IV pressure ulcers for residents with darkly pigmented skin (0.56 per person per year) compared with residents with lighter skin tones (0.35 per person per year) ($p < 0.001$). In a multivariable analysis that also considered resident and facility characteristics, race was significantly associated with pressure ulcer development (hazard ratio 1.31, 95% confidence interval [CI] 1.02 to 1.66, $p = 0.032$). These assessment techniques are therefore important to use in identifying darkly pigmented skin.

Rosen et al. (2006)⁵ found similar disparities between nursing home residents with dark skin tones and those with light skin at the beginning of a quality improvement program. The quality improvement program consisted of education on assessing subtle differences in skin color and texture and assessment of skin warmth. The intervention also included implementation of a repositioning reminder system, individual financial incentives, and a disincentive system that included staff termination. At 12-week follow up, significantly fewer residents with darkly pigmented skin had a new Category/Stage II to IV pressure ulcer than at baseline ($p < 0.004$), and there was a significant reduction in Category/Stage I to IV pressure ulcers for both residents with dark skin tones ($p < 0.004$) and lighter skin ($p < 0.05$). The quality improvement program that included staff education on skin assessment eliminated the racial disparities noted at baseline (Level 3 study).

Conducting Skin and Tissue Assessment

1. **In individuals at risk of pressure ulcers, conduct a comprehensive skin assessment:**
 - as soon as possible but within eight hours of admission (or first visit in community settings),
 - as part of every risk assessment,
 - ongoing based on the clinical setting and the individual's degree of risk, and
 - prior to the individual's discharge. (Strength of Evidence = C; Strength of Recommendation = 👍)

- 1.1. **Increase the frequency of skin assessments in response to any deterioration in overall condition. (Strength of Evidence = C; Strength of Recommendation = 👍)**

These statements are based on expert opinion. Conduct a head-to-toe assessment with particular focus on skin overlying bony prominences including the sacrum, ischial tuberosities, greater trochanters and heels.^{6,7} Each time the patient is repositioned is an opportunity to conduct a brief skin assessment.

- 1.2. **Document the findings of all comprehensive skin assessments. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Accurate documentation is essential for monitoring the progress of the individual and aiding communication between professionals.⁶

2. **Inspect skin for erythema in individuals identified as being at risk of pressure ulceration. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Caution: Avoid positioning the individual on an area of erythema wherever possible.

This statement is based on expert opinion. Ongoing assessment of the skin is necessary in order to detect early signs of pressure damage. Visual assessment for erythema (redness of the skin) is the first component of every skin inspection. Skin redness and tissue edema resulting from capillary occlusion is a response to pressure, especially over bony prominences.

- 2.1. **Differentiate the cause and extent of erythema. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Differentiate whether the skin redness is blanchable or nonblanchable.

Blanchable erythema is visible skin redness that becomes white when pressure is applied and reddens when pressure is relieved. It may result from normal reactive hyperemia that should disappear within several hours or it may result from inflammatory erythema with an intact capillary bed.^{8,9}

Nonblanchable erythema is visible skin redness that persists with the application of pressure. It indicates structural damage to the capillary bed/microcirculation. This is an indication for a Category/Stage I pressure ulcer.⁸ In addition, a prospective cohort study of 109 individuals in an acute care hospital found nonblanching erythema to be an independent predictor of Category/Stage II pressure ulcer development ($p = 0.002$) (Level 3 study).³

- 2.2. **Use the finger or the disc method to assess whether skin is blanchable or non-blanchable. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Studies are mixed regarding two commonly used methods to assess erythema are:^{9,10}


- finger pressure method — a finger is pressed on the erythema for three seconds and blanching is assessed following removal of the finger; and
- transparent disk method — a transparent disk is used to apply pressure equally over an area of erythema and blanching can be observed underneath the disk during its application.

Vanderwee et al. (2006)⁹ investigated the reliability of both the finger press and the transparent disk methods of assessing erythema in a cohort of participants with erythema from an acute care geriatric ward (n = 265). Assessments were conducted by a researcher and nurses, all of whom were provided with training on the assessment methods at the commencement of the study. Participants were assessed independently by a researcher and a nurse within 30 minutes of each other and using both assessment methods. Both assessment techniques had high interrater reliability between nurses and researchers. Agreement for the finger press method was $\kappa = 0.69$ for all body locations, $\kappa = 0.78$ for sacrum assessments and $\kappa = 0.63$ for heel assessments. Sensitivity ranged from 65.3% (heels) to 73.1% (all body locations) and specificity ranged from 93.9% (sacrum) to 95.8% (heels). For the transparent disk method, interrater reliability ranged from 0.67 (heels) to 0.79 (sacrum); sensitivity ranged from 67.2% (heels) to 86.1% (sacrum) and specificity ranged from 93.4% (sacrum) to 96.1% (heels). Interrater agreement was excellent between the two assessment methods ($\kappa = 0.83$ to 0.90). The results were similar for reliability amongst the nurses and amongst the researchers. Agreement increased with years of nursing experience and with education levels. The researchers suggested that the transparent disk method has advantages over the finger press method as the level of pressure applied to the skin is less variable between assessors and blanching is observable immediately on application of pressure, which increases ease of assessment in individuals with rapid vascular refill (Level 2 study).

Kottner et al. (2009)¹⁰ compared prevalence of Category/Stage I pressure ulcers using two identification methods. Facilities involved in the prevalence survey were randomly assigned to use either the finger press method of depressing skin to assess blanching following removal of the finger (n = 5,095 assessments) or to use a transparent disc to assess blanching as the pressure is applied (n = 4,657 assessments). The finger method was more likely to identify a Category/Stage I pressure ulcer (odds ratio [OR] = 1.80, 95% confidence interval [CI] 1.49 to 2.18, $p < 0.001$) (Level 3 study).

However, Sterner et al. (2011)⁸ reported low interrater reliability for the finger press method in their prospective cohort study conducted with individuals aged over 65 years with hip fractures (n = 78, all participants were Caucasian). Sacral skin assessments that included a visual inspection and a finger press test were conducted daily for up to five days by independent, blinded assessors. For the day one assessments, interrater reliability was lower for the finger press test ($\kappa = 0.44$, 95% CI 0.21 to 0.67) than for visual inspection ($\kappa = 0.67$, 95% CI 0.5 to 0.82). By day five, interrater reliability for the finger press test decreased to 0.20 (95% CI -0.06 to 0.46), while interrater reliability increased slightly for the visual inspections ($\kappa = 0.76$, 95% CI 0.61 to 0.91). The researchers concluded that neither strategy was a reliable method to use as the sole strategy by which to discriminate between blanching and nonblanching erythema. In this study the assessors received no specific training and their level of experience and education was not reported. (Level 4 study).

3. Include the following factors in every skin assessment:

- skin temperature;
- edema; and
- change in tissue consistency in relation to surrounding tissue. (Strength of Evidence = B; Strength of Recommendation = )

Localized heat, edema and change in tissue consistency in relation to surrounding tissue (e.g., induration/hardness) have all been identified as warning signs for pressure ulcer development.^{6, 7, 9, 11}


Rosen et al. (2006)⁵ implemented a quality improvement program that consisted of education on assessing subtle differences in skin color and texture and assessment of skin warmth. The intervention also included implementation of a repositioning reminder system, individual financial incentives, and a disincentive system that included staff termination. At 12 week follow-up, there was a significant reduction in Category/Stage I to IV pressure ulcers for both residents with dark skin tones ($p < 0.004$)

and lighter skin ($p < 0.05$). The quality improvement program that included staff education on skin assessment eliminated the racial disparities noted at baseline (Level 3 study).

Farid et al. (2012)¹² conducted a retrospective review of records for 85 individuals with intact pressure-related discoloration to the skin who received skin temperature readings as part of the skin assessment. All temperature assessments were conducted using a handheld thermographic device to take skin temperature at both pressure-related discolored areas and adjacent normal skin. At the time of the initial skin assessment, approximately 65% of participants had a lower skin temperature reading in the pressure-related discolored skin region compared to the adjacent skin. The pressure-related discolored region was significantly more likely to progress to skin necrosis within seven days than in participants with higher skin temperature readings in the discolored skin region (OR = 31.8, 95% CI 3.8 to 263.1, $p = 0.001$). There was a trend toward a positive relationship between darker skin tone and progression of the discolored region to necrosis (OR = 7.7, 95% CI 0.8 to 70.8, $p = 0.07$). The wide confidence intervals suggest that there is some uncertainty in these findings and further research is required (Level 4 study).

Small, laboratory studies conducted in healthy individuals provide preliminary evidence on other novel skin assessment techniques, including changes in skin tissue blood flow associated with pressure measured using photoplethysmogram (PPG) and laser doppler flowmetry (LDF)^{13, 14} and measures of transcutaneous oxygen¹⁵ (indirect evidence). These strategies require further investigation to ascertain their reliability and validity as measures of underlying skin damage.

3.1. When conducting a skin assessment in an individual with darkly pigmented skin prioritize assessment of:

- **skin temperature;**
- **edema; and**
- **change in tissue consistency in relation to surrounding tissue. (Strength of Evidence = B; Strength of Recommendation = )**

As it is not always possible to identify erythema on darkly pigmented skin; localized heat, edema, and change in tissue consistency in relation to surrounding tissue (e.g., induration/hardness) are important indicators of early pressure damage to the skin in individuals of darker skin tone. As reported above, there is evidence to support inclusion of these criteria in a comprehensive skin assessment.

There is evidence indicating that early skin damage is under-detected in dark skinned individuals. A higher rate of full-thickness ulcers in individuals with darkly pigmented skin compared to lighter skin tones suggests that detection, and therefore treatment, is delayed until full-thickness injury is apparent.

VanGilder et al. (2008)¹⁶ reported an international pressure ulcer prevalence study that included an examination of the relationship between pressure ulcer development and skin tone (light, medium and dark). Category/Stage I pressure ulcers were proportionately lower in individuals with dark skin tones (13%) compared with individuals who had medium skin tones (32%) and light skin tones (38%). There was little difference in the percentages of Category/Stage II ulcers by skin tone: 36.8% for light tones, 39.3% for medium tones and 41.3% in those with dark toned skin. However, there was a greater percent of Category/Stage III and IV pressure ulcers in individuals with dark skin tone. Category/Stage III pressure ulcers occurred in 6.2% of light toned participants and 6.7% of those with medium toned skin, compared with 10.8% of individuals with dark skin tones. A similar pattern was seen in Category/Stage IV pressure ulcers: 5.5% of light toned individuals, 6.8% of those with medium skin tones and 12.9% of those with dark toned skin.

In a study of 1,938 residents of 59 nursing homes, Baumgarten et al. (2004)⁴ reported a significantly higher rate of Category/Stage II to IV pressure ulcers for individuals with darkly pigmented skin (0.56 ulcers per person year) compared to individuals with light skin tones (0.35 ulcers per person year) ($p < .001$). Race was significantly associated with pressure ulcer development in a multivariate analysis that also considered resident and facility characteristics.

As cited above, Rosen et al. (2006)⁵ also found similar disparities between pressure ulcer rates for individuals with dark skin tones compared to individuals with light skin tones. This pattern is a recurrent trend in pressure ulcer prevalence and incidence studies.¹⁷⁻²¹ Astute assessment of intact skin in dark skinned individuals is critical in reversing this trend.

In the study by Rosen et al. (2006)⁵ cited above, the implementation of a quality improvement program that included provision of education on assessing subtle differences in skin color and texture and assessment of skin warmth showed significant improvements in pressure ulcer rates for individuals with darkly pigmented skin, such that the significant racial disparities noted at baseline were eliminated by the intervention. At 12 week follow-up, significantly fewer residents with darkly pigmented skin had a new Category/Stage II to IV pressure ulcer than at baseline ($p < 0.004$), and there was a significant reduction in Category/Stage I to IV pressure ulcers for both residents with dark skin tones ($p < 0.004$) and lighter skin ($p < 0.05$) (Level 3 study).

In recent studies (reported below), Bates-Jensen et al. (2009)²² introduced the concept “sub-epidermal moisture” as a tissue assessment parameter. Firstly, some sub-epidermal moisture in sub-epidermal tissue is normal, because extracellular fluid within the tissue facilitates electrolyte transfer around the body and contributes to skin turgor. Thus the term “sub-epidermal moisture” and its assessment is essentially a measurement of soft tissue edema. This parameter is a potential marker for inflammation. Further clinical studies are required to establish a threshold value for abnormal versus normal moisture levels, and to confirm the predictive reliability of sub-epidermal moisture readings.

Bates-Jensen et al. (2009)²² investigated the use of a hand-held surface electrical capacitance dermal phase meter for detecting sub-epidermal moisture in darkly pigmented skin. In their earlier study conducted in nursing home residents ($n = 31$) the research team established higher sub-epidermal moisture in skin that was visually assessed to be damaged (Level 4 study).²³ In the follow-up study, sub-epidermal moisture values predicted the incidence of Category/Stage II or greater pressure ulcers developing within one week in individuals with dark skin tones. The sub-epidermal moisture reading identified local tissue edema that was not visually identifiable in darkly pigmented skin for up to ten days following the sub-epidermal moisture assessment (Level 4 study). Although this method of assessment may improve identification of Category/Stage I pressure ulcers in darker skin, these initial studies were small, did not clearly report on recruitment or establish interrater reliability and were not powered to measure the reported outcomes.

3.2. Assess localized pain as part of every skin assessment. (Strength of evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Studies have identified pain as a major factor for individuals with pressure ulcers. Several studies also offer some indication that pain over the site was a precursor to tissue breakdown.²⁴⁻²⁶ When the individual is able to respond reliably, ask him or her to identify any areas of discomfort or pain that could be attributed to pressure damage. Other strategies for assessing pain associated with pressure ulcers are discussed in detail in the *Pain Assessment and Treatment* section of this guideline.

4. Inspect the skin under and around medical devices at least twice daily for the signs of pressure-related injury on the surrounding tissue. (Strength of evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Frequently inspect the skin beneath adjustable medical devices and continue to lift and/or move the medical device for pressure relief. Be aware of tubes and medical devices that can become entrapped in skin folds resulting in skin damage, especially in the bariatric population.²⁷

4.1. Conduct more frequent (greater than twice daily) skin assessments at the skin-device interface in individuals vulnerable to fluid shifts and/or exhibiting signs of localized/generalized edema. (Strength of evidence= C; Strength of Recommendation = 👉👉)

This statement is based on expert opinion. Changes in fluid volume status, or hypoproteinemic states can result in localized or generalized edema causing a medical device that initially fits properly to exert external pressure to the skin that leads to pressure ulcer formation.²⁸ The health professional should not apply any type of medical device without being cognizant of the potential for tissue expansion and worsening edema. Depending on the type/purpose of the device, loosening, replacement or removal (e.g., compression stockings) may be advised.

Further recommendations can be found in the guideline section *Medical Device Related Pressure Ulcers*.

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PREVENTIVE SKIN CARE

Introduction

Maintaining skin integrity is essential in the prevention of pressure ulcers. Alterations in skin status, including dry skin and existing pressure ulcers, are consistently identified as a risk factor for development of a new pressure ulcer in epidemiological studies.¹⁻⁶ See the *Risk Factors and Risk Assessment* section of the guideline for further discussion.

Maintaining healthy skin requires comprehensive assessment and care planning. Nutrition and hydration, addressed in the appropriate section of this guideline, play an important role in skin health. Appropriate management of other skin conditions (e.g., eczema, incontinence-associated dermatitis) is also an imperative in maintaining the skin's integrity and ability to protect underlying tissues.

This chapter addresses direct care of the skin to reduce the risk of pressure ulcers. Preventive skin care not only protects the skin and promotes comfort, but also provides an opportunity to conduct a skin assessment and identify areas at risk that may require further preventive care and/or changes to the individual's overall pressure ulcer prevention plan. The use of prophylactic dressings to protect the skin is discussed in the section *Emerging Therapies for the Prevention of Pressure Ulcers*.

Recommendations

- 1. Avoid positioning the individual on an area of erythema whenever possible. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Erythema indicates that the body has not recovered from the previous loading and requires further respite from repeated loading. Both the finger press and the disc method are appropriate strategies to use for skin assessment and differentiation between blanchable and non-blanchable erythema. The guideline chapter *Skin and Tissue Assessment* discusses the importance of regular skin assessment, and the implications of different types of erythema.

- 2. Keep the skin clean and dry. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Cleansing the skin removes dirt, moisture, sebum and oils from the skin's surface. Frequency of cleansing should be individualized; over-cleansing can cause the skin to become dry due to removal of the skin's natural protective layers.⁷ Select soft fabrics for washers and towels to prevent skin damage. Ensure the skin is dry after cleansing and pay particular attention to skin folds.

- 2.1. Use a pH balanced skin cleanser. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

The pH of the skin at the surface measured when refraining from washing or using cleansers ranges from 4.0 to 7.0 (slightly acidic to neutral).⁸ Using a pH balanced skin cleanser reduces potential dryness, erythema and irritation (risk factors for breaches to skin integrity) that can arise due to interaction between high pH soap products and the proteins and lipids on the skin's surface.⁷

Cooper et al. (2001)⁹ investigated a standard hospital soap (1% aqueous solution with a pH of 9.5 to 10.5; n = 49) compared to a foam no-rinse cleanser (combination of an emollient, water-repellant deodorant and water-repellant barrier with a pH of 5.5; n = 44). The randomized trial was conducted over 14 days in a hospital and a nursing home and participants were required to have some form of incontinence or catheterization to be included. Skin was assessed using the Stirling Pressure Severity Scale and classified as broken skin (Category/Stage II pressure ulcer or above), erythematous (Category/Stage I pressure ulcer) or healthy (no alterations to skin integrity). Overall, skin condition was maintained or improved for more participants receiving the

cleanser compared with the soap and water (66% versus 37%, $p = 0.05$). Participants who were classified as having healthy skin at commencement of the trial experienced more erythema (30.3% versus 15.1%, $p =$ not reported) and more broken skin (12.1% versus 0%, $p =$ not reported) when their skin was cleansed with soap and water. Although the median lengths of stay in care facilities were significantly different between the groups, the condition of skin was not significantly different between the groups on entry to the study (Level 2 study).

3. Do not massage or vigorously rub skin that is at risk of pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)

In the past, massage has been used as a method of pressure ulcer prevention.¹⁰⁻¹² Various types of massage use combinations of different stroke types including:¹³

- Effleurage – slow, gentle gliding strokes that use firm pressure;
- Pertissage – forceful kneading and skin rolling used on fleshy body regions;
- Tapotement – striking and percussive movements;
- Friction – compressive, penetrating pressure; and
- Vibration – shaking or vibrating motions.

Less vigorous massage techniques are reported to have beneficial outcomes for healthy tissue through increasing blood flow to the area, resulting in increased tissue suppleness and parasympathetic activity, relaxed muscle tone, and reduced edema. However, even these less vigorous massage techniques are contraindicated in the presence of acute inflammation and where there is the possibility of damaged blood vessels or fragile skin.^{13, 14}

In a randomized crossover trial, Duimel-Peeters et al. (2007)¹⁵ included 79 nursing home residents in three study groups. One group received massage with a placebo cream, another group received massage with dimethyl sulfoxide cream (DMSO), and the control group received no massage or cream application. The massage was conducted using soft, circular motions with a gloved hand (effleurage) to the coccyx, heels and ankles. The three groups received a 30° position change every six hours and were lying on a polyurethane pressure redistribution support surface. No significant difference in pressure ulcer incidence was found between the three regimens. The odds ratio (OR) of developing a pressure ulcer when massaged with a placebo cream was 1.135 ($p = 0.441$) in the first half of the trial and 2.526 ($p = 0.516$) in the cross over period. The OR for massage with DMSO cream was 2.571 ($p = 0.126$) in the first period of the trial and 2.182 ($p = 0.516$) in the second period. In the first half of the trial the OR for developing a pressure ulcer when no cream or massage was applied was 0.636 ($p = 0.350$) and in the second part of the trial OR was 0.063 ($p = 0.007$). The researchers found no benefit from the use of massage; in fact there was some advantage to not massaging the individual (Level 2 study). It should be noted DMSO cream is not recommended in preventive skin care (see recommendation below) and is not approved for use on humans in the US.

Friction massage involves the use of penetrating pressure and is a vigorous type of rubbing described in older nursing texts.¹⁶ As well as being painful, it can cause mild tissue destruction or provoke inflammatory reactions, particularly in frail older adults. Early work by Dyson (1978)¹⁷ examining skin biopsies taken at post-mortem found cellular damage in areas where the skin had been rubbed compared to biopsies taken from individuals who had not had their skin rubbed (indirect evidence).

4. Develop and implement an individualized continence management plan. (Strength of Evidence = C; Strength of Recommendation = 👍👍)


4.1. Cleanse the skin promptly following episodes of incontinence (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Incontinence can lead to prolonged skin exposure to excess moisture and chemical irritants in urine and feces. In addition, occlusion resulting from the use of an incontinence aid can alter the microclimate of the skin. The overall result can be


inflammation, erythema, erosion, and denudation with decreased tolerance to other forms of skin damage, such as that associated with prolonged exposure to pressure or shear.¹⁸ An incontinence management plan aims to reduce the incidence of incontinent episodes and prompt cleansing reduces the duration of skin exposure to irritants. See *Recommendation 2* above for further information on skin cleansing.

In individuals with significant incontinence, catheterization and fecal containment devices are sometimes implemented to aid in skin hygiene. However, these devices are associated with increased risk of medical device related pressure ulcers,¹⁹ so the benefits versus the risk of harm should be considered carefully according to the individual's clinical condition before incorporation into the continence management plan. If used, the recommendations in the guideline section on *Medical Device Related Pressure Ulcers* provide guidance on minimizing the risk of medical device related pressure ulcers.

Pittman et al. (2012)²⁰ explored the use of two fecal management devices, a bowel management system catheter (BMS group, n = 21) and a rectal trumpet utilized as a fecal incontinence device (RT group, n = 20) compared with usual care (n = 18) in a randomized, controlled trial (RCT) conducted in a critical care setting. The usual care consisted of cleansing with a remoistened wipe and application of a zinc-based barrier cream. The study was conducted until the end-point of device failure (three or more incontinent stools in a 24 hour period), device complications (including rectal bleeding) or discharge from the critical care unit. There was no significant difference in the number of pressure ulcers present in any of the groups (BMS 42.9% versus RT 35% versus usual care 27.8%, p = 0.63). The usual care group experienced lower levels of incontinence-associated dermatitis. The relatively high rate of pressure ulcers was contributed to by the high level of pressure ulcers present on entry to the study (32% of participants). There was also a wide variation in time spent in the study (from 2 days to 60 days), which may have influenced the findings (Level 2 study).

5. Protect the skin from exposure to excessive moisture with a barrier product in order to reduce the risk of pressure damage. (Strength of Evidence = C; Strength of Recommendation = )

This statement is based on expert opinion. It is important to note that skin damage from moisture is not a pressure ulcer, but that presence of skin damage from moisture may increase the risk of pressure ulceration. The mechanical properties of the stratum corneum are changed by the presence of moisture and as a function of temperature. The stiffness of the stratum corneum at 20% humidity is a factor 1,000 lower than at 100% humidity. The strain at which the stratum corneum breaks is approximately four times higher at 100% humidity, compared to dry skin. Humidity also increases the friction coefficient between the skin and supporting surface, thus enhancing the risk of shear damage.²¹⁻²⁸


6. Consider using a skin moisturizer to hydrate dry skin in order to reduce risk of skin damage. (Strength of Evidence = C; Strength of Recommendation = )

In a multivariate analysis of risk factors in 286 hospitalized individuals with limited mobility, dry skin was found to be a significant and independent risk factor for pressure ulcers.³

The most appropriate skin moisturizer has yet to be determined, and studies on moisturizer products in preventive skin care have mixed results. One study by Bou et al. (2005)²⁹ investigated hyperoxygenated fatty acids for pressure ulcer prevention. The research team undertook a double blind RCT (n=164) comparing a product containing fatty acids (Mepentol®) with a product containing trisostearin and perfume (n = 167). The products were applied twice daily to the sacrum, trochanter and heels. There was a significant reduction in pressure ulcer incidence associated with use of the product containing fatty acids (17.3% versus 7.32%, p = 0.006) at 30 day follow up. The study report did not include the methods of randomization and the analysis was not intention-to-treat (results for only 87% of the recruited population were reported) (Level 2 study).

Verdú et al. (2012)³⁰ investigated the use of Iparazine-4A-SKR (described as a galenic formula containing hyperoxygenated fatty acids) for preventing pressure ulcers in individuals at high risk of pressure ulcers (Braden score ≤ 15) in hospitals and social health centers in Spain. Participants were gently massaged, until the cream was absorbed, every 12 hours on the sacrum, trochanters and heels with either Iparazine-4A-SKR (n = 99) or a placebo topical product (n = 95). There was no significant difference in facility-acquired pressure ulcer rates between the group receiving the Iparazine-4A-SKR and the group receiving the placebo cream (6.1% versus 7.4, p = 0.94). The trial was conducted over a period of 14 days and both groups received the same additional standard pressure ulcer prevention interventions (Level 2 study).

In a quality improvement study conducted in a medical ward Shannon et al. (2009)³¹ reported that the use of a silicon-based dermal nourishing moisturizer was associated with a significant reduction in risk of incontinent individuals in a medical unit developing a pressure ulcer (p = 0.008). Rates of pressure ulcers reduced from a high of 31% to an average of 7%. However, confounding issues, including concurrent changes in staffing, were not addressed in the report (Level 4 study).

6.1. Do not use dimethyl sulfoxide (DMSO) cream for the prevention of pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = )

Caution: DMSO cream is not approved for use on humans in US, but is sometimes used as a topical application in other countries.

One RCT compared a topical administered antioxidant, 5% DMSO cream (n = 29), to a placebo Vaseline cream (n = 32). The experimental and placebo creams were both massaged into the buttocks, heels and ankles every six hours for four weeks. A third group receiving only regular repositioning (n = 18) was used to control for a possible effect of massage. A high rate of Category/Stage I and II pressure ulcers was reported (44% across all anatomical locations and groups). The group receiving DMSO cream massage had a significantly higher incidence of pressure ulcers at the heel/ankle location (OR = 8.80, 95% CI 2.61 to 29.6). There was no difference in pressure ulcer rates between the group receiving the placebo cream and the control group, thereby excluding a potential negative effect of massage as influencing the findings³² (Level 2 study).

In one cross-over RCT reported above, Duimel-Peeters et al. (2007)¹⁵ found no significant difference in pressure ulcer rates between individuals massaged with DMSO cream and those massaged with a placebo cream. The odds ratio (OR) of developing a pressure ulcer when a placebo cream was applied was 1.135 (p = 0.441) in the first half of the trial and 2.526 (p = 0.516) in the cross over period. The OR for developing a pressure ulcer when DMSO cream was applied was 2.571 (p = 0.126) in the first period of the trial and 2.182 (p = 0.516) in the second period (Level 2 study).

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EMERGING THERAPIES FOR PREVENTION OF PRESSURE ULCERS

Introduction

The comprehensive literature review conducted for the guideline revision revealed a body of evidence on new and emerging therapies for preventing pressure ulcers. This section of the guideline presents the evidence on these new and emerging therapies, including microclimate manipulation; fabrics designed to reduce shear and friction; prophylactic dressings and electrical stimulation of muscles in individuals with spinal cord injury.

Microclimate Control

There is a growing appreciation of the effects of microclimate in pressure ulcer formation and healing. Microclimate is the term used to describe the local tissue temperature and moisture (relative humidity) at the body/support surface interface. One study conducted in older adults ($n = 20$) suggested that positioning may influence microclimate, due to the influence on skin temperature of alterations in superficial blood flow associated with changes in body positioning.¹ Pressure alone may also lead to increases in skin temperature.²

Elevated temperature increases metabolic rate³ in tissue and promotes fibroblast growth and scarring.⁴⁻⁶ Thus, hospitalized individuals with elevated skin temperatures and perspiration are at possible increased risk of pressure ulcers.⁷ One study has demonstrated that elevating the sacral skin temperature is associated with statistically significant ($p < 0.017$) increase in hyperemia in response to applied pressure at the sacrum in both healthy volunteers and individuals with spinal cord injury (SCI). Conversely, the same study demonstrated that cooling the skin by approximately 10°C was associated with reduced hyperemia in response to pressure for individuals with and without SCI⁸ (indirect evidence). However, some individuals with SCI may have alterations in their ability to modulate temperature. Animal studies (using incremental tissue loading levels) have also showed a direct dose response to heat in formation of both deep and superficial ulceration.^{9,10}

Elderly individuals have been shown to have reduced ability to dissipate excess heat via the vascular system, resulting in additional skin warming for a given stimulus.¹¹ High levels of moisture on the skin surface (e.g., due to incontinence, drainage and/or perspiration) reduce skin tensile strength, and intracellular cohesion of the stratum corneum, and increase the skin coefficient of friction. These cellular changes result in skin maceration.¹²

In a cohort study set in Indonesia, Yusuf et al. (2013)¹³ took regular hourly skin temperature and moisture readings at the sacral region of hospitalized participants ($n = 86$ recruited, $n = 71$ completed the study) considered to be at risk of pressure ulcers (Braden score less than 19). Daily skin assessments were conducted to identify pressure ulcers and superficial skin changes, which occurred in 28% of participants. The physical environment had a high humidity and an average room temperature of 30°C , with the study conducted in the Indonesian dry season. Although there was no significant difference in sacral skin temperature between participants who did and did not develop pressure ulcers, the results bordered on significant ($p = 0.07$). In addition, participants who developed pressure ulcers had significantly lower overall Braden scores (odds ratio [OR] = 0.347, 95% confidence interval [CI] 0.206 to 0.585, $p = 0.00$), including significantly lower scores on the moisture subscale ($p=0.00$). The study was hampered by high room humidity that decreased the reliability of skin temperature measurement, and skin temperature was not measured overnight (Level 3 study).

Management of microclimate can provide an environment conducive to prevention and tissue repair.

1. Consider the need for additional features such as ability to control moisture and temperature when selecting a support surface. (Strength of Evidence = C; Strength of Recommendation = 👉)

This recommendation is based primarily on expert opinion. The use of specialized surfaces that come into contact with the skin may be able to alter the microclimate by changing the rate of evaporation of moisture and the rate at which heat dissipates from the skin.¹⁴ Specialized support surfaces that aid active management of microclimate by allowing air to flow through their surfaces,¹⁴ for example low air loss features or air fluidized beds, are available. The constant air flow helps to cool the skin and promote evaporation of moisture from the skin surface.¹⁴ Low air loss support surfaces are designed to assist with microclimate management, but in the absence of evidence outlining optimal levels of skin temperature and moisture levels, clinical judgment is required for effective and safe use of these devices.¹⁴

1.1. Consider the need for moisture and temperature control when selecting a support surface cover. (Strength of Evidence = C; Strength of Recommendation = 👉)

Any surface that is in contact with the skin will have the potential to affect the microclimate. The overall effect is dependent on the nature of the support surface and its type of cover.¹⁴ For example, a foam mattress will transfer heat and moisture differently dependent upon the porosity of the cover.¹⁴ The use of a vapor permeable support surface cover can draw moisture and heat through the contact layer and away from the skin. Indirect evidence from a study conducted in healthy volunteers indicated that plastic mattress coverings were associated with greater drops in skin temperature in extremities compared with conventional cotton mattress covers¹⁵ (indirect evidence).

Synthetic silk-like sheets, the research on which is cited below (see the subsection *Fabrics and Textiles*), may also contribute to changes in microclimate; however, further research on this possible mechanism is required. Although a cohort study by Yusuf et al. (2013)¹³ failed to provide a thorough evaluation of the potential influence of synthetic sheets on microclimate, the authors established that synthetic sheets were associated with a lower incidence of pressure ulcers than 100% cotton sheets, and also established a non-significant trend toward higher sacral skin temperatures in participants who developed a pressure ulcer or superficial skin changes (Level 3 study).

2. Do not apply heating devices (e.g., hot water bottles, heating pads, built-in bed warmers) directly on skin surfaces or pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👉)

Heat increases the metabolic rate, induces sweating and decreases the tolerance of the tissue for pressure. When the body heat cannot dissipate, it will increase the risk of skin maceration and may impede healing.¹²

Prophylactic Dressings

Ohura et al. (2005)¹⁶ used an *invitro* porcine model to measure pressure and shear forces on skin and subcutaneous tissue. Shear forces on both layers of tissue were decreased when various dressings were applied to the skin. This suggests that testing of the ability of dressings to mitigate shearing effects in humans is warranted. Emerging evidence supports a role of prophylactic dressings in decreasing friction and reducing localized shear forces.¹⁷

Specific characteristics that may contribute to the dressings' ability to absorb shear and friction force were further explored in a laboratory study conducted by Call et al. (2013)¹⁸. Features such as an elastic adhesive type (e.g., silicone), the number of dressing layers and their construction, and the size of the selected dressing all contributed to its ability to protect the skin.

The use of prophylactic dressings to protect skin from medical devices is discussed in the guideline section *Medical Device Related Pressure Ulcers*.

1. Consider applying a polyurethane foam dressing to bony prominences (e.g., heels, sacrum) for the prevention of pressure ulcers in anatomical areas frequently subjected to friction and shear. (Strength of Evidence = B; Strength of Recommendation = 👉)

Four studies^{17, 19-21} demonstrate a reduction in the occurrence of pressure ulcers in at risk anatomical locations when a prophylactic polyurethane foam dressing was applied. In three of these trials, participants were critically ill, immobile individuals in intensive care.^{17, 20, 21}

Santamaria et al. (2013)²⁰ conducted a randomized, controlled trial (RCT) in which adults for intensive care unit (ICU) admission were randomized in the emergency department to receive a soft silicone multi-layered foam dressing applied to the heels and sacrum or to a control group receiving standard pressure ulcer prevention (not described). After transfer to the ICU, skin assessments were performed every two to four hours. Dressings were changed every three days or earlier if dislodged or soiled. There was a significant reduction in overall pressure ulcer incidence (4.3% versus 17.8%, $p = 0.002$); heel pressure ulcer incidence (3.1% vs 12.5%, $p = 0.002$); and sacral pressure ulcer incidence (1.2% versus 5.2%, $p = 0.05$) associated with the prophylactic dressing. Santamaria et al. (2013)²⁰ calculated a number needed to treat (NNT) of 10 to prevent any pressure ulcer. The study and analysis was non-blinded and the Category/Stage of pressure ulcers that occurred was not reported. The authors considered that the multi-layer design of the dressing may contribute to its effectiveness and recommended more study of this dressing feature (Level 2 study).

In a study of high risk ICU individuals, only one patient of 50 (2%) who received a self-adherent silicone border foam dressing applied to the sacrum developed a pressure ulcer compared to four out of 35 (11.4%) individuals who received standard care interventions.¹⁷ While the findings were not significant in this underpowered study, the data present a trend that suggests a preventive application for this dressing type (Level 3 study).

Another small study ($n = 62$) conducted in an ICU reported a decline in the incidence of sacral pressure ulcers (from approximately 20% to 4.8% over two years) in individuals at high risk who received a silicone border foam dressing; however, the intervention was introduced with a concurrent change in continence management, and the study had no control group²¹ (Level 5 study).

In a study of a polyurethane foam, hydrocellular dressing, Torra I Bou et al. (2009)¹⁹ found a significant reduction in heel pressure ulcers treated with a foam dressing compared to a protective heel bandage that covered the ankle articulation. Participants ($n = 133$, $n = 111$ completed the study) were recruited from three long term facilities and three home care programs in Spain. Approximately 3% individuals in the foam dressing group developed pressure ulcers compared to 44% in the protective bandaging group. Relative risk of developing a pressure ulcer was 13.42 (95% CI 3.31 to 54.3) for the bandaging group compared to the prophylactic dressing group. It should be noted that heel flotation was not used as a preventive management strategy, and the bandaging intervention used as a control is not considered current best practice (Level 2 study).

2. When selecting a prophylactic dressing consider:

- **ability of the dressing to manage microclimate;**
- **ease of application and removal;**
- **ability to regularly assess the skin;**
- **anatomical location where the dressing will be applied; and**
- **the correct dressing size. (Strength of Evidence = C; Strength of Recommendation = 👉)**

Prophylactic dressings differ in their qualities; therefore it is important to select a dressing that is appropriate to the individual and the clinical use. A polyurethane foam dressing has greater ability to absorb moisture than film or hydrocolloid dressings,^{20, 22} and are often designed with easy to lift borders.^{17, 21} Some dressings are designed to adhere well to the skin; however if they are not removed carefully there is increased risk of damage to fragile skin.^{23, 24} Dressings are now being specifically designed for anatomical locations at which it has been historically difficult to apply dressings.

A laboratory study investigating the characteristics of prophylactic dressings identified the dressing construction, including the presence of multiple layers within the dressing structure and the type of adhesion (e.g., silicone adhesive has elastic quality), as playing an important role in reducing shear and friction forces at the point of application. Additionally, the study found that proper sizing of the dressing is important in order that there is adequate displacement of forces from the skin that is at pressure ulcer risk¹⁸ (indirect evidence).

Research also indicates that prophylactic dressings influence the microclimate. In one laboratory study the construction of dressings was found to significantly influence moisture trapping and humidity close to the skin. The accumulation of moisture at the skin surface decreased the ability of some dressings to transpire. Although heat at the skin surface increases with the application of prophylactic dressings, heat rise was considered insufficient to place the skin at additional risk of injury.²⁵

3. **Continue to use all other preventive measures necessary when using prophylactic dressings. (Strength of Evidence = C; Strength of Recommendation = 👍)**
4. **Assess the skin for signs of pressure ulcer development at each dressing change or at least daily, and confirm the appropriateness of the current prophylactic dressing regimen. (Strength of Evidence = C; Strength of Recommendation = 👍)**
5. **Replace the prophylactic dressing if it becomes damaged, displaced, loosened or excessively moist. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Prophylactic dressings do not negate the need for thorough and regular skin assessment, therefore their design often facilitates regular skin assessments (e.g., soft silicone borders that are easy to lift for routine skin checks without creating tape burns or other skin injuries). In the studies reported above, foam prophylactic dressings were replaced every three days, or earlier if soiled or dislodged^{17, 20, 21} and net stockings were used to protect prophylactic dressings applied to heels.^{19, 20}

Fabrics and Textiles

1. **Consider using silk-like fabrics rather than cotton or cotton-blend fabrics to reduce shear and friction. (Strength of Evidence = B; Strength of Recommendation = 👍)**

Four studies reviewed the effectiveness of utilizing lower friction coefficient textiles to reduce friction force and shear stresses.

The first study²⁶ was a RCT that compared two groups. Cohort one participants wore regular hospital garments (n = 204) and cohort two were assigned low friction fabric undergarments or booties (n = 165). The incidence of facility-acquired pressure ulcers was significantly lower in the second cohort (25% versus 41%, p = 0.02). There was a lower rate of wound deterioration for participants admitted with an existing pressure ulcer in the second cohort (6% versus 25%, p = 0.001).²⁶ The study concluded that the use of low friction garments was associated with a reduced incidence of pressure ulcers amongst those assessed as being at high risk. In individuals who did acquire a pressure ulcer, the lower friction undergarments were associated with reduced deterioration of pressure ulcers.²⁶ While these results suggested that the use of low friction coefficient material reduced pressure ulcers, the methodological flaws were numerous (Level 2 study).

A non-blinded, controlled trial by Coladonato et al. (2012)²⁷ was conducted over eight weeks. During the control period all participants were positioned on cotton-blend linen. The control period was repeated after the intervention period. During the intervention period silk-like bed linen was used. The study identified that silk-like linen was associated with a lower incidence of pressure ulcers among individuals in a medical/surgical setting as compared to cotton-blend linen. In the medical unit, the average length of stay was shorter for the silk-like linen cohort (5.31 versus 5.97 days, p = 0.07) and the incidence of new pressure ulcers was lower (4.6% versus 12.3%, p = 0.01). The surgical ICU showed similar results

with a decrease in pressure ulcer incidence (0% versus 7.5%, $p = 0.01$), though the average length of stay did not show a statistically significant difference ($p = 0.33$) (Level 3 study).

A cohort study conducted by Yusuf et al. (2013)¹³ included an analysis of the influence of sheet selection in development of pressure ulcers. In a multivariate analysis, type of sheeting was one of two significant factors (the other being Braden scale score). Participants ($n = 86$, 71 completed study) who received 100% cotton sheeting were more likely to develop a pressure ulcer than those who had a synthetic fiber sheeting (OR = 0.11, 95% CI 0.012 to 1.032, $p = 0.00$). However, the confidence interval spans the null value, suggesting caution in considering the results (Level 3 study).

A retrospective record analysis ($n = 1,427$) conducted by Smith et al. (2013)²⁸ explored the association between pressure ulcer incidence and silk-like linen compared with a cotton-blend fabric. In this study the historical control participants experienced significantly more facility-acquired Category/Stage I pressure ulcers than the intervention group (5.6% versus 2.3%, $p < 0.001$). The silk-like sheets were also associated with a significantly lower rate of Category/Stage II pressure ulcers (5.95 versus 0.8%, $p < 0.001$). Participants in the intervention group discharged during the three month intervention period were significantly less likely to have a pressure ulcer at the time of discharge compared to the control group (13.45% versus 6.8%, $p < 0.001$). Retrospective analysis for the control group spanned the holiday period, and the potential influence of more casual nursing staff members on pressure ulcer incidence was not discussed (Level 4 study).

Electrical Stimulation of the Muscles for Prevention of Pressure Ulcers

There is emerging evidence that electrical stimulation (ES) induces intermittent tetanic muscle contractions and reduces the risk of pressure ulcer development in at risk body parts, especially in individuals with spinal cord injury (SCI). Electrical stimulation may decrease tissue atrophy by increasing muscle mass, improving blood flow and tissue oxygenation. The periodic muscle contractions redistribute the loading and stiffness of the deformed soft tissues. This method appears practical in daily life and is well tolerated.^{29, 30}

1. **Consider the use of electrical stimulation for anatomical locations at risk of pressure ulcer development in spinal cord injury patients. (Strength of Evidence = C; Strength of Recommendation = Ⓢ)**

This recommendation is based on indirect evidence and expert opinion. Two clinical experiments, one a moderate quality comparative study³⁰ and one a low quality cross-over RCT,²⁹ investigated the effect of ES induced activation of the gluteal and hamstring muscles on the sitting pressure distribution in individuals with SCI. Subjects received ES in their own wheelchair while sitting pressure was measured. During an ES procedure the participants wore special ES shorts with built-in electrodes over the gluteus and hamstrings. Biphasic pulsed current (BPC) was applied with a frequency of 50 pps to induce tetanic muscle contractions. The current amplitude ranged from 70 to 115 mA (average 94 ± 12.5 mA) in the study by Smit et al. (2012)³⁰ and from 70 to 80 mA in the study by Janssen et al. (2010)²⁹ (indirect evidence).

In the study by Janssen et al. (2010)²⁹ five participants completed two 3-hour sessions of ES, both consisting of three minutes of stimulation (all muscles simultaneously activated) followed by 17 minutes of rest. Intervention A consisted of a three minute stimulation cycle, with 1-second on: 1-second off. Intervention B consisted of a three minute stimulation cycle with 1-second on: 4-seconds off. Peak and mean pressure under the tuber areas were calculated throughout the ES session. All participants ($n = 10$) in the study by Smit et al. (2012)³⁰ completed two 1-hour protocols of ES, both consisting of three minutes of stimulation and a 17 minute rest period. A cycle of 1-second stimulation and 4-seconds off was performed within each three minutes of ES. During the first one hour of ES the gluteal muscles were stimulated, and during the next hour of ES gluteal and hamstrings muscles were stimulated. In both studies the difference between mean pressure under the tuber area and surrounding sensors was calculated. This pressure gradient may indicate shear forces – a high pressure gradient is associated with high shear forces within the tissue, increasing the risk of a pressure ulcer developing (indirect evidence).

Janssen et al. (2010)²⁹ reported that for both interventions A and B the peak pressure decreased significantly ($p < 0.05$) during the three hour stimulation periods. The pressure gradient tended ($p < 0.1$) to decrease for both intervention protocols indicating an improved pressure distribution. Within the three minute stimulation, muscle fatigue occurred only during intervention A. As no differences in maximal pressure reductions were found between the first, second and third hours of stimulation sessions, the authors concluded that 17 minutes rest between the 3 minute stimulation cycles in intervention A (1-second on:1-second off) and in intervention B (1-second on:4-seconds off) was sufficient to obtain full muscle rest. Smit et al. (2012)³⁰ found both gluteal and gluteal-plus-hamstring muscle activation gave significant interface pressure relief, but activation of gluteal-plus-hamstring muscles gave significantly more mean pressure relief than activation of gluteal muscles only. Pressure gradient reduced significantly (49.3%, $p = 0.01$) only after stimulation of gluteal-plus-hamstring muscles (indirect evidence).

The authors of the above studies concluded that ES induced tetanic contractions of the gluteal and hamstring muscles in sitting individuals with SCI causes a temporary decrease in peak sitting pressure under the tuber area and an improved pressure distribution. ES procedures should be applied for 1 to 3 hours/day with a 50 pps current in an intermittent cycle: 3 min of stimulation (including 1-second on:1-second off or 1-second on:4-seconds off) and 17 minutes of rest. However, it must be observed that a protocol with longer rest periods (1-second on:4-seconds off) results in larger pressure reductions and less muscle fatigue²⁹ so it seems a more effective stimulation method. Stimulation of gluteal and hamstring muscles appears to be more effective than stimulating only the gluteal muscles³⁰ (indirect evidence).

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INTERVENTIONS FOR PREVENTION & TREATMENT OF PRESSURE ULCERS

NUTRITION IN PRESSURE ULCER PREVENTION AND TREATMENT

Introduction

The recommendations in this section of the guideline are predominantly for adult individuals and have been derived from evidence conducted in adult populations. Recommendations for nutritional assessment and treatment in pediatric populations are presented in the section *Special Populations: Pediatric Individuals*.

Nutrition is the process of ingesting carbohydrates, protein, fat, vitamins, minerals, and fluids in sufficient amounts to meet nutritional requirements. Malnutrition is simply defined as any nutritional imbalance.¹ It is a condition in which a nutritional deficiency or an excess or imbalance of energy, protein, and other nutrients causes measurable adverse effects on tissue, body structure, body function, and clinical outcomes. In this guideline, malnutrition primarily refers to a status of undernutrition.

Thomas (2008)² noted that recent weight loss in older adults was a key factor in mortality risk. Murden et al. (1994)³ indicated that a 10% decline in weight over a six month period was a strong predictor of mortality in this population. A retrospective study by Fry et al. (2010)⁴ noted malnutrition and/or weight loss correlated with a fourfold higher risk of developing a pressure ulcer. Two studies support the theory that individuals in long-term care with a body weight that has declined by 5% in 30 days were at increased risk of death.^{5, 6} Thomas (2007)⁷ described the “anorexia of aging” as including appetite decline, weight loss and decreased metabolic rate, all of which can place the older adult at risk for malnutrition. Unintended weight loss is a well-validated risk factor for malnutrition; however, bariatric adults may also be poorly nourished.

Identifying individuals who exhibit these characteristics is important because malnutrition is associated with many adverse outcomes, including the risk of pressure ulcers and impaired wound healing. In 2012 the Academy of Nutrition and Dietetics (the Academy) and the American Society for Parenteral and Enteral Nutrition (ASPEN) recommended that a standardized set of diagnostic characteristics be used to identify and document adult malnutrition in routine clinical practice.⁸ Adult malnutrition usually occurs along a continuum of inadequate intake and/or increased requirement, impaired absorption, altered transport, and compromised nutrient utilization. Individuals may also have hypermetabolic and/or hypercatabolic and inflammatory conditions. The consensus statement by the Academy and ASPEN defines malnutrition as the presence of two or more of the following characteristics:⁸

- insufficient energy intake,
- unintended weight loss,
- loss of muscle mass,
- loss of subcutaneous fat,
- localized or generalized fluid accumulation, and/or
- decreased functional status.

Serum albumin and prealbumin are generally not considered reliable indicators of nutritional status. The Academy’s Evidence Analysis Library analyzed change in serum albumin and prealbumin with weight loss, anorexia nervosa, non-malabsorptive gastric partitioning, calorie restricted diets and nitrogen balance. The analysis concluded that changes in acute phase proteins do not consistently or predictably change with weight loss, calorie restriction or nitrogen balance.⁹ They appear to reflect severity of inflammatory response rather than nutritional status. Inflammation can increase the risk of malnutrition by increasing metabolism. Thus the relevance of laboratory values as indicators of malnutrition is limited.⁸ It should be noted that people with a daily energy intake of less than 6.3 MJ (1,500 kcal) often have an insufficient intake of vitamins and minerals.¹⁰

Malnutrition and Pressure Ulcers


Malnutrition impacts pressure ulcer healing. Both inadequate nutritional intake and poor nutritional status (malnutrition) have been shown to correlate to the development of pressure ulcers, pressure ulcer severity, and protracted healing of wounds.¹¹⁻¹³ Yamamoto et al. (2009)¹⁴ reported a correlation between energy intake and pressure ulcer healing. In addition to malnutrition, dehydration is a common yet under recognized problem in individuals with, or at risk of, a pressure ulcer. Dehydration contributes to skin fragility, increasing its susceptibility to breakdown.¹⁵

As discussed in detail in the guideline section *Risk Factors and Risk Assessment*, multivariable analysis of epidemiological data indicates that a poor nutritional status (malnutrition) and variables that indicate potential malnutrition (e.g., low body weight and poor oral food intake) are independent risk factors for the development of pressure ulcers.¹⁶⁻¹⁸ Moreover, it appears that many acute and chronically ill individuals who are at risk of developing pressure ulcers or have an established pressure ulcer suffer from unintended weight loss.^{11, 17-20}

Numerous studies conducted in a number of countries and clinical settings have demonstrated a relationship between malnutrition and pressure ulcers. A study in the US evaluating the care process for hospitalized Medicare individuals (n = 2,425) aged 65 years and older and assessed as being at risk for pressure ulcers noted that 76% of the study population was malnourished.²¹ In an Australian study conducted in public acute and aged care facilities, Banks et al. (2010)²² concluded that the odds ratio (OR) of having a pressure ulcer was 2.6 (95% confidence interval [CI] 1.8 to 3.5) for adults with malnutrition in acute care and 2.0 (95% CI 1.5 to 2.7) for adults with malnutrition in aged care. In a prognostic case-control study investigating the relationship between nutritional status and pressure ulcer development in individuals aged over 65 years who were receiving home care in Japan, Iizaka et al. (2010)¹³ found the rate of malnutrition was significantly higher in those with a pressure ulcer (58.7% versus 32.6%, p < 0.001). Malnutrition was also significantly associated with more severe pressure ulcers; the OR of having a full thickness pressure ulcer with malnutrition was 1.88 (95% CI 1.03 to 3.45). Verbrugge et al. (2013)²³ conducted an analytical cross sectional study investigating prognostic factors for malnutrition in 23 nursing homes in Belgium (n = 1,188 older adults). Multivariate logistic regression in which the dependent variable was a score of less than 17 (malnourished) on the Mini Nutritional Assessment full version (MNA) showed that the presence of pressure ulcers was a potential predictor of malnutrition (OR = 5.02, 95% CI 1.69 to 14.92, p < 0.01). The researchers concluded that the presence of pressure ulcers is one of the major factors independently associated with malnutrition in older nursing home residents. In a small (n = 31) observational study, Wojcik et al. (2011)²⁴ showed that adults with pressure ulcers receiving home living support in the US may be at risk for nutritional deficits due to an unsatisfactory dietary intake that may delay wound healing.

Nutrition Screening

1. Screen nutritional status for each individual at risk of or with a pressure ulcer:

- at admission to a health care setting;
- with each significant change of clinical condition; and/or
- when progress toward pressure ulcer closure is not observed. (Strength of Evidence = C; Strength of Recommendation = )

Poor outcomes, including the risk of morbidity and mortality, are associated with malnutrition; hence the need to quickly identify and treat malnutrition when pressure ulcers are present. Nutrition screening is the process used to identify individuals who require a comprehensive nutrition assessment due to characteristics that put them at potential nutritional risk. Any qualified member of the health care team may complete nutrition screening, and it should be conducted on admission to the health care facility, or at first visit in community settings.

A cross-sectional study investigating the role of clinical guidelines in the assessment and management of patients with pressure ulcers found that adopting a formalized, facility-wide nutritional guideline

contributes to the continuing practice of regular nutritional screening in daily practice. Introduction of a nutritional guideline was also shown to reduce barriers to providing nutritional support.²⁵

2. Use a valid and reliable nutrition screening tool to determine nutritional risk. (Strength of Evidence = C; Strength of Recommendation = )

It is important that the screening tool is validated, reliable, and relevant to the patient group being assessed. The screening tool should consider current weight status (e.g., underweight or obesity), as well as past and likely future change in weight, both of which are linked to food intake/appetite and disease severity. It is important that the screening tool is capable of establishing nutritional risk in all types of individuals, including those with fluid disturbances and those in whom weight and height cannot be easily measured.^{26, 27} There are numerous valid and reliable nutrition screening tools available for use in specific clinical settings and populations. The most commonly used tools for screening adults are reported below.


The MNA[®] is a validated nutrition screening and assessment tool (n.b., the MNA[®] refers to the MNA short form version that is recommended for clinical use). Langkamp-Henken et al. (2005)²⁸ conducted a cross-sectional study (n = 23) in older males with pressure ulcers in residential aged care investigating correlation of the tool with MNA[®] scores and clinical indicators. There was a significant positive correlation between MNA[®] scores and nutritional indicators including body mass index (BMI; $r = 0.66$, $p = 0.0006$), calf circumference ($r = 0.46$, $p = 0.0286$), hemoglobin ($r = 0.43$, $p = 0.0409$), hematocrit ($r = 0.44$, $p = 0.0358$) and fat mass index ($r = 0.50$, $p = 0.0275$). In a German study comparing the nutritional status of individuals with and without pressure ulcers, the researcher concluded that the MNA[®] is easy to use for assessing older adults with pressure ulcers and multiple comorbidities.²⁹

The MNA[®] is the only nutrition screening tool that has specifically been validated in individuals with pressure ulcers.³⁰ The MNA[®] is also validated for identifying older adults at nutritional risk in both community and long term care settings.^{30, 31} In a comparative study of six different nutrition screening tools used in a sample of 248 older adults, Poulia et al. (2012)³² established the MNA[®] had a sensitivity of 98.1% and a specificity of 75% for identifying nutritional risk.






The Malnutrition Universal Screening Tool (MUST) has been validated in acute care, long term care and community settings. Poulia et al. (2012)³² concluded that the MUST was the most appropriate tool for evaluating the risk of malnutrition in older adults admitted to hospital, with a high sensitivity (87.3%) and a high negative predictive value (75%) for identifying nutritional risk.

The Nutrition Risk Screening 2002 (NRS) is validated for screening nutritional risk in adults in hospital. In terms of predictive validity, clinical outcomes improve when individuals identified by the NRS to be at nutrition risk are treated. Reliability between observers has been established ($\kappa = 0.67$).²⁶ The tool has high sensitivity (99.4%) and high negative predictive value (83.3%) for identifying nutritional risk in older adults.³²

The Short Nutrition Assessment Questionnaire (SNAQ) has been validated in both hospital and residential care adult populations. Weight change, appetite, supplements and tube feeding are the parameters of the SNAQ. Neelemant et al. (2008)³³ demonstrated validity of the tool in a population of pre-operative adults with a mean age of 49 years, of which 12% were screened as moderately or severely malnourished. Using a cut-off score of 2 points or more, the SNAQ had a sensitivity of 67% (95% CI 52% to 79%) and a specificity of 98% (95% CI 97% to 99%). In the same study, the sensitivity of the tool was lower in an outpatient population (59%, 95% CI 42 to 72%).³³

3. Refer individuals screened to be at risk of malnutrition and individuals with an existing pressure ulcer to a registered dietitian or an interprofessional nutrition team for a comprehensive nutrition assessment. (Strength of Evidence = C; Strength of Recommendation = )

Nutrition Assessment


1. **Assess the weight status of each individual to determine weight history and identify significant weight loss ($\geq 5\%$ in 30 days or $\geq 10\%$ in 180 days). (Strength of Evidence = C; Strength of Recommendation = )**
2. **Assess the individual's ability to eat independently. (Strength of Evidence = C; Strength of Recommendation =  )**
3. **Assess the adequacy of total nutrient intake (i.e., food, fluid, oral supplements and enteral/parenteral feeds). (Strength of Evidence = C; Strength of Recommendation =  )**

These statements are based on expert opinion and indirect evidence. All adults at risk for malnutrition based on the results of nutrition screening should be referred to a registered dietitian or an interprofessional nutrition team for a comprehensive nutritional assessment.³⁴ A comprehensive nutrition assessment involves a systematic process of collecting, verifying, and interpreting data related to nutritional status, and forms the basis for all nutrition interventions.³⁵ The assessment process is continuous, and early intervention is critical.

A comprehensive nutrition assessment should be conducted by a registered dietitian in consultation with the interprofessional team (including, but not limited to, a physician, nurse, speech pathologist, occupational therapist, physical therapist and dentist). The focus of nutrition assessment should be on evaluating energy intake, unintended weight change and the effect of psychological stress or neuropsychological problems. Additionally, assessment should include a determination of the individual's caloric, protein and fluid requirements.

Biochemical laboratory data may not be available or cost effective in every clinical setting. Current research indicates that serum protein levels may be affected by inflammation, renal function, hydration, and other factors. Serum albumin, prealbumin and other laboratory values may be useful in establishing the individual's overall prognosis; however, they may not correlate well with clinical observation of nutritional status.^{8, 36-38} Fuhrman et al. (2004)³⁹ reported evidence suggesting that serum hepatic proteins correlate with mortality and morbidity; are useful indicators of illness severity; and help identify individuals at risk for developing malnutrition. Hepatic protein levels do not accurately measure nutritional repletion.⁴⁰ Thus, serum concentrations may not be markers of malnutrition or caloric repletion, but instead may be indicators of morbidity severity and risk of mortality. As of 2012, the Academy and ASPEN do not recommended using inflammatory biomarkers for diagnosis of malnutrition.⁸

Care Planning

1. **Develop an individualized nutrition care plan for individuals with or at risk of a pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = )**

A registered dietitian, in consultation with the interprofessional team (including, but not limited to, a physician, nurse, speech pathologist, occupational therapist, physical therapist and dentist) should develop and document an individualized nutrition intervention plan based on the individual's nutritional needs, feeding route and goals of care, as determined by the nutrition assessment. Monitoring and evaluation of nutritional status is an ongoing process and the management plan should be adjusted with each change in the individual's clinical condition.

Allen (2013)⁴¹ conducted a quasi-experimental study examining the effect of a comprehensive, interprofessional nutritional protocol that included consultation with an occupational therapist, registered dietitian and speech therapist; regular (pre-) albumin assessments; and protein and vitamin/mineral supplementation on pressure ulcer healing in individuals aged over 60 years. Participants were recruited from an acute long term care hospital in the US and compared with a control

group obtained via a retrospective record analysis (n = 100). The study concluded that, for older adults, an interprofessional nutritional intervention that includes protein and vitamin/mineral supplementation may contribute to increased pressure ulcer healing assessed as percent tissue regeneration (Level 4 study).

2. **Follow relevant and evidence-based guidelines on nutrition and hydration for individuals who exhibit nutritional risk and who are at risk of pressure ulcers or have an existing pressure ulcer. (Strength of Evidence=C; Strength of Recommendation = 👍)**

Energy Intake

1. **Provide individualized energy intake based on underlying medical condition and level of activity. (Strength of Evidence = B; Strength of Recommendation = 👍)**
2. **Provide 30 to 35 kcalories/kg body weight for adults at risk of a pressure ulcer who are assessed as being at risk of malnutrition. (Strength of Evidence = C; Strength of Recommendation = 👍)**
3. **Provide 30 to 35 kcalories/kg body weight for adults with a pressure ulcer who are assessed as being at risk of malnutrition. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**
4. **Adjust energy intake based on weight change or level of obesity. Adults who are underweight or who have had significant unintended weight loss may need additional energy intake. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

The National Academy of Sciences, Institute of Medicine, and Food and Nutrition Board, in partnership with Health Canada, defined estimated energy requirements needed to maintain energy balance in a healthy individual.⁴² The requirements are defined by age, gender, weight, height, and activity. These requirements form the basis for determining baseline caloric needs. The Trans Tasman Dietetic Wound Care guidelines for adults with pressure injuries also recommend 30 to 35 kcalories/kg body weight for individuals with moderate to high risk of delayed healing due to nutritional concerns.³⁰ Guidelines by the European Society for Clinical Nutrition and Metabolism also recommend 30 to 35 kcalories/kg body weight nutritional support for most chronic conditions in individuals at risk of malnutrition.⁴³

Energy needs are currently assessed using several methods. The methods used for predictive formulas or energy needs measurement should be defined for the relevant individual population (e.g., critically ill or obese). Research indicates that the original Harris-Benedict equation is inaccurate for calculating energy requirements.⁴⁴ Cereda et al. (2011)⁴⁵ noted the estimation of energy needs for adults with pressure ulcers using Harris-Benedict formula should consider a correction factor based on the underestimation of 10% of energy needs. This review supported the goal of 30 kcalories/kg/day but noted limitations of the meta-analysis, including a small number of included studies, small sample sizes and heterogeneity of the groups. The Mifflin-St. Jeor equation may be more accurate and have a smaller margin of error when used to calculate resting metabolic rate for obese but otherwise healthy individuals.⁴⁶ Measured energy requirements (i.e., indirect calorimetry), if available, are a more accurate measure of energy expenditure; however, may be cost prohibitive in many settings.

A randomized, controlled trial (RCT) investigating the effectiveness of a nutritional intervention that uses calorie calculation according to basal energy expenditure (BEE) in promoting pressure ulcer healing was conducted by Ohura et al. (2011)⁴⁷. Mean daily calories administered during the intervention period were 1,092.1 ± 161.8 kcalories (29.1 ± 4.9 kcalories/kg/day) in the control group and 1,383.7 ± 156.5 kcalories (37.9 ± 6.5 kcalories/kg/day) in the intervention group, with both groups receiving enteral rather than oral feeding. It should be noted that individuals receiving enteral feeding generally have low energy needs when compared with mobile individuals receiving oral nutrition. Statistically significant increases were noted for the intervention group over the control group for weight (p < 0.001), waist circumference (p < 0.001), supra iliac skinfold thickness (p < 0.005) and thigh circumference (p < 0.005). Pressure ulcers healed within 12 weeks for four subjects in the control group and seven subjects in the

intervention group. Pressure ulcer depth decreased steadily in the intervention group ($p < 0.05$). The researchers concluded that a nutritional intervention calculated using $BEE \times activity\ factor\ 1.1 \times stress\ factor\ 1.3\ to\ 1.5$ may be associated with increased pressure ulcer healing in older adults receiving tube feeding. This was a small study ($n = 60$) and inclusion was limited to participants receiving enteral feeding who were not mobile. Additionally, the high calorie group also received higher levels of protein (Level 2 study).

In a retrospective study, Yamamoto et al. (2009)¹⁴ investigated the total nutritional intake of individuals with pressure ulcers to determine the level of energy intake needed to heal pressure ulcers. In individuals showing an improvement or healing of pressure ulcers the daily energy intake over 12 weeks was greater than 30 kcalories/kg body weight. Individuals who experienced worsening or no improvement in the pressure ulcer had an energy intake of no greater than 20 kcalories/kg body weight (Level 3 study).

- 5. Revise and modify/liberalize dietary restrictions when limitations result in decreased food and fluid intake. These adjustments should be made in consultation with a medical professional and managed by a registered dietitian whenever possible. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Caloric needs are ideally met by a healthy diet; however, some individuals are unable or unwilling to consume an adequate diet. Overly restricted diets may make food unpalatable and unappealing, and therefore reduce intake. The Academy's 2010 position statement⁴⁸ emphasizes the enhancement of quality of life for older adults residing in health care facilities by reduction in dietary restriction through individualization of dietary intake. Thus, it is recommended that health professionals assess the risks versus benefits of overly restrictive and/or therapeutic diets, especially for older adults. For example, an individual may not consume adequate nutrients on a sodium restricted diet, thus leading to malnutrition and delayed pressure ulcer healing. In addition, macronutrient sources of calories should follow a healthy pattern. A healthy diet includes 45% to 65% of calories from carbohydrates. The synthesis of glucose (gluconeogenesis) by the liver and kidneys is more fuel efficient than breaking down protein and fat for energy; protein is needed for collagen synthesis.

- 6. Offer fortified foods and/or high calorie, high protein oral nutritional supplements between meals if nutritional requirements cannot be achieved by dietary intake. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

The type and amount of food and fluid ingested daily should be reviewed periodically to ensure that the individual actually consumes the number of calories required to meet nutrient needs. Oral nutritional supplements (ONS), enhanced foods, and food fortifiers can be used to combat unintended weight loss and malnutrition. Oral nutritional supplements include products that supply nutrients including protein, carbohydrates, fat, vitamins, minerals, and/or amino acids.

Stratton et al. (2005)⁴⁹ pooled the results of four RCTs comparing ONS with routine care (i.e., following a normal diet and implementing routine pressure ulcer care) and one RCT comparing enteral tube feeding to routine care. The results of the meta-analysis showed that oral nutritional supplementation (mainly high protein, 400 to 500 kcal, duration of 4 to 72 weeks) was associated with a significant reduction in pressure ulcer development compared to routine care (OR = 0.75; 95% CI 0.62 to 0.89, $n = 1,224$). When the one additional study investigating enteral tube feeding was included in the meta-analysis the result remained similar (OR = 0.74; 95% CI 0.62 to 0.88, $n = 1,325$) (Level 1 study).

In a retrospective cohort study that included 1,524 residents in long-term care facilities, the prescription of any ONS was associated with a decreased likelihood of developing a Category/Stage I or greater pressure ulcer (OR = 0.57, 95% CI 0.36 to 0.90, $p = 0.016$). The relationship remained significant when analysis was limited to development of a Category/Stage II or greater pressure ulcer (OR = 0.43, 95% CI 0.25 to 0.72, $p = 0.001$)¹⁵ (Level 5 study).

A study conducted by Wilson et al. (2002)⁵⁰ indicated that healthy adults aged over 70 years who consumed high calorie, high protein oral liquid supplements between meals experienced better absorption of nutrients, with the least interference to meal intake (indirect evidence).

- 7. Consider enteral or parenteral nutritional support when oral intake is inadequate. This must be consistent with the individual's goals. (Strength of Evidence = C; Strength of Recommendation = 👍)**

If oral intake is inadequate, enteral or parenteral nutrition may be recommended if consistent with the individual's wishes. Enteral (tube) feeding is the preferred route if the gastrointestinal tract is functioning. The risks and benefits of nutrition support should be discussed with the individual and caregivers early on, and should reflect the individual's preferences and goals for care. Routine assessment should confirm that individuals are actually receiving the amount of tube-feeding solution prescribed.

One RCT⁵¹ evaluated the effect of additional tube feeding on the incidence of pressure ulcers in 129 hospital patients with a hip fracture. The experimental group (n = 62) was treated with a standard hospital diet and an additional nasogastric tube feeding (1,000 mL of 1,500 kcal/l; 60 g/l protein) that was administered with a feeding pump overnight. Participants in the control group (n = 67) received the standard hospital diet alone. The pressure ulcer incidence (Category/Stage II or greater) after two weeks was 52% in the experimental group and 57% in the control group. The difference between the two groups was not statistically significant (p = 0.12), indicating that enteral feeding had no influence on healing in this population. However, the duration of the trial was very short (Level 2 study).

A cohort study by Teno et al. (2012)⁵² examined the effectiveness of tube feeding in preventing pressure ulcers or promoting their healing. Study participants included 461 subjects with both a pressure ulcer and a percutaneous endoscopic gastrostomy (PEG) tube. Results showed that the risk of new Category/Stage II or greater pressure ulcers was more than twice as high (OR = 2.27, 95% CI 1.95 to 2.65) when a PEG was present. The risk of a new Category/Stage IV pressure ulcer when a feeding tube was present was OR = 3.31 (95% CI 2.14 to 4.89). In participants who had a PEG inserted, 27.2% of pressure ulcers improved compared with 34.6% in participants with no PEG (OR = 0.66, 95% CI 0.45 to 0.97). The increased risk may be related to increased diarrhea, increased immobility or comorbidities, but this was not investigated. The investigators concluded that PEG feeding tubes are not beneficial and may be associated with increased risk of pressure ulcers (Level 4 study).

Protein Intake

- 1. Provide adequate protein for positive nitrogen balance for adults assessed to be at risk of a pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍)**
- 2. Offer 1.25 to 1.5 grams protein/kg body weight daily for adults at risk of a pressure ulcer who are assessed to be at risk of malnutrition when compatible with goals of care, and reassess as condition changes. (Strength of Evidence = C; Strength of Recommendation = 👍)**
- 3. Provide adequate protein for positive nitrogen balance for adults with a pressure ulcer. (Strength of Evidence = B; Strength of Recommendation = 👍)**
- 4. Offer 1.25 to 1.5 grams protein/kg body weight daily for adults with an existing pressure ulcer who are assessed to be at risk of malnutrition when compatible with goals of care, and reassess as condition changes. (Strength of Evidence = B; Strength of Recommendation = 👍)**
- 5. Offer high calorie, high protein nutritional supplements in addition to the usual diet to adults with nutritional risk and pressure ulcer risk, if nutritional requirements cannot be achieved by dietary intake. (Strength of Evidence = A; Strength of Recommendation = 👍)**
- 6. Assess renal function to ensure that high levels of protein are appropriate for the individual. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Protein is essential for promoting positive nitrogen balance. Increased protein levels have been linked to improved healing rates.^{51, 53} Clinical judgment is required to determine the appropriate level of protein for each individual, based on the number of pressure ulcers present, overall nutritional status, co-morbidities, and tolerance to nutritional interventions. For example, adults with chronic kidney disease may be inappropriate candidates for high levels of protein. The health professional must assess renal function to ensure appropriate tolerance of higher protein levels.⁵⁴

Calculate the individual's protein requirements and make determinations on any nutritional interventions. The Institute of Medicine⁵⁵ recommendation for 0.8 g protein/kg body weight for a healthy adult is considered inadequate for pressure ulcer prevention and healing, especially for older adults. Based on metabolic changes and the loss of lean muscle (sarcopenia) that occurs with aging, other clinical guidelines recommend protein levels above the level recommended by the Institute of Medicine. The Trans Tasman evidence-based guideline for dietetic management of adults with pressure ulcers recommends 1.25 to 1.5 g protein/kg body weight daily for individuals at moderate to high risk for delayed healing of pressure ulcers due to nutritional concerns.³⁰ Since aging is associated with decreased protein and energy intake and a decline in muscle mass, the *2010 Nutritional Recommendations for the Management of Sarcopenia* published by the Society for Sarcopenia, Cachexia and Wasting Disease recommended total protein intake should be 1 to 1.5 g/kg body weight for older adults.⁵⁶ The PROT-AGE Study Group evidence-based guideline recommends a protein intake of 1.2 to 1.5 g/kg body weight for older adults with acute or chronic disease, and suggests that those with severe illness or injury may need 2.0 g/kg body weight daily.⁵⁷

The previously reported RCT by Ohura et al. (2011)⁴⁷ investigated the effectiveness of a nutritional intervention based on a calorie calculation according to BEE in promoting the healing of pressure ulcers. The intervention group, who received a high level of calories, also received high mean levels of protein (1.62 g/kg/day) compared to the control group that received a mean daily protein intake of 1.24 g/kg/day. A statistically significant decrease in wound size was noted after week eight for the intervention group compared to the control group (Level 2 study).

In a RCT conducted by Cereda et al. (2009)⁵⁸, which is described in more detail below, a high calorie (30 kcalories/kg/day) high protein (1.5 g/kg /day; n = 13) nutritional approach resulted in faster healing as assessed by reduction in wound area and Pressure Ulcer Scale for Healing (PUSH) score compared to a high calorie (30 kcalorie/kg body weight daily), normal protein (1.2 g/kg/day) nutritional regimen (n = 15) (Level 2 study). It should be noted that a normal protein (16% of total energy) intervention of 30 kcalories/kg/day provides at least 1.2 grams of protein/kg body weight daily. The amount of protein intake increases to 1.4 g/kg body weight with a 35 kcalorie/kg/day nutritional support intervention. In a high protein support (20% of total energy) the amount of protein provided to individuals would amount to 1.5 to 1.75 g/kg/day (Level 2 study).

The review by Stratton et al. (2005)⁴⁹ showed that oral nutritional supplementation with high levels of protein and calories (16% to 32% energy as protein, 400 to 50 kcalories, duration of 4 to 72 weeks) was associated with a significant reduction in pressure ulcer development compared to routine care (4 RCTs, OR = 0.75; 95% CI 0.62 to 0.89, n = 1,224) (Level 1 study).

7. Supplement with high protein, arginine and micronutrients for adults with a pressure ulcer Category/Stage III or IV or multiple pressure ulcers when nutritional requirements cannot be met with traditional high calorie and protein supplements. (Strength of Evidence = B; Strength of Recommendation = 👍)

Growing, but still moderate quality evidence supports a positive effect of nutritional supplementation with additional protein, arginine and micronutrients to promote pressure ulcer healing. Certain amino acids such as arginine become conditionally essential amino acids during periods of stress.

Cereda et al. (2009)⁵⁸ conducted a single blinded RCT investigating a disease specific nutritional approach as a strategy to promote pressure ulcer healing. Participants with Category/Stage II or greater pressure ulcers residing in four long term care facilities in Italy received similar general pressure ulcer

care. Participants (n = 15, but 2 deceased leaving n = 13) randomized to the intervention group received either a standard hospital diet with additional 400 mL of an oral supplement containing 500 kcalories, 34 g protein, 6 g arginine, 500 mg vitamin C, 18 mg zinc or, for those being tube fed, 1,000 mL high protein formula (20% energy from protein enriched with arginine, zinc and vitamin C) infused with isocaloric formula to reach energy requirements. The control group (n = 15) received a regular hospital diet consisting of 16% energy from protein or standard enteral formula. Both groups had significant improvement in pressure ulcer healing (p < 0.001 for both groups). Primary outcomes were pressure ulcer area and percent of wound healed assessed using the PUSH tool. Both groups showed significant improvement in pressure ulcer healing (p < 0.001 for both groups). The PUSH score became statistically significantly different between both groups at week 12 (favored treatment, p < 0.05) and the difference in ulcer area was significant by week eight (favored treatment, p < 0.05). The researchers concluded that the rate of pressure ulcer healing in older adults appears to accelerate when a nutrition formula enriched with protein, arginine, zinc and vitamin C is administered for at least eight weeks (Level 2 study).

In one RCT, van Anholt et al. (2010)⁵⁹ investigated a high protein, arginine and micronutrient rich supplement (the same formula as administered in the study of Cereda et al. (2009)⁵⁸) to improve healing in well-nourished adults with Category/Stage III and IV pressure ulcers. Participants (n = 43) were recruited from eight health care centers, hospitals, and long term care facilities in four European countries. Participants were randomly allocated to receive either a high energy ONS enriched with 20 g protein, 3 g arginine, antioxidants, 250 mg vitamin C, 38 mg vitamin E (α-tocopherol equivalents), 238 mg vitamin A, 9 mg zinc, 1.35 mg copper, 64 μg selenium and 200 μg folic acid in amounts of 200 mL three times daily between meals for eight weeks (n = 22) or 200 mL non-caloric placebo on the same regimen (n = 21). Supplementation with the specific ONS accelerated pressure ulcer healing, as indicated by a significantly different decrease in ulcer size compared with the control over the study period (p = 0.016). The decrease in PUSH severity score in the ONS group differed significantly (p = 0.033) from the control. Moreover, significantly fewer dressings were required per week in the ONS group compared with the control (p = 0.045) and less time was spent per week changing the dressings (p = 0.022). The researchers concluded that a nutritional supplement with high protein, arginine and micronutrients may be associated with improved pressure ulcer healing in older adults who do not have pre-existing malnutrition (Level 2 study). The positive results attained in this study would be stronger if they had been achieved in a study using an isonitrogenous and isocaloric placebo rather than a non-caloric placebo.

Brewer et al. (2010)⁶⁰ conducted an historical control study investigating the effect of arginine supplementation in promoting healing of pressure ulcers in community-dwelling individuals with spinal cord injury (SCI). The intervention group that took a supplement equivalent to 9 g arginine daily showed superior healing compared to the control group (10.5 ± 1.3 weeks to complete healing versus 21.1 ± 3.7 weeks, p = 0.006). There was no statistically significant difference in healing rates between participants with and without diabetes in the intervention group (p = 0.894) or between participants with and without diabetes in the historical control group (p = 0.994). All participants in the intervention group consumed at least 85% of supplement doses until full healing was achieved. The authors concluded that arginine supplementation of 9 g daily may be associated with faster pressure ulcer healing in individuals with SCI (Level 5 study).

Chapman et al. (2011)⁶¹ conducted an observational study investigating pressure ulcer healing in individuals with SCI recruited from inpatient and outpatient services in Australia (n = 34) and receiving arginine supplements (9 g daily). Results showed that 41% of participants ceased the supplement prior to full healing. There was no statistically significant difference in time to healing of Category/Stage III pressure ulcers between those who ceased treatment (mean 14.3 ± 7.3 weeks) and those who completed the full course of treatment (11.4 ± 2.0 weeks, p = not significant [ns]). There was also no statistically significant difference in time to healing of Category/Stage IV pressure ulcers between those who ceased treatment (mean 31.3 ± 13.6 weeks) and those who completed (11.4 ± 2.0 weeks, p = ns). When healing of Category/Stage III and IV pressure ulcers was combined, a 2.5 fold greater rate of healing was observed in those who continued supplementation until full healing compared with those who ceased taking the supplement (8.5 ± 1.1 weeks versus 20.9 ± 7.0 weeks, p=0.04). The researchers

concluded that an arginine supplement may be associated with improved healing rates of Category/Stage III and IV pressure ulcers in individuals with SCI (Level 5 study).

A RCT by Leigh et al. (2012)⁶² compared different doses of arginine for healing pressure ulcers in participants recruited from acute inpatient and rehabilitation wards of an Australian hospital (n = 23). All participants had standard pressure ulcer care throughout the study. Participants were randomized to receive either a standard hospital diet plus 4.5 g arginine daily for three weeks (n = 12) or standard hospital diet with the addition of 9 g arginine per day for three weeks (n = 11). There was a significant decrease over time ($p < 0.001$) in pressure ulcer severity assessed using the PUSH tool with no evidence of a statistically significant difference between the two arginine dosages ($p = 0.991$). Individuals categorized as malnourished showed clinically significant impaired healing rates compared with well-nourished participants ($p = 0.057$) although this was unaffected by arginine dosage ($p = 0.727$). There was no significant difference in healing rates based on arginine dosage ($p = 0.393$). The authors concluded that arginine was associated with increased healing compared with historical controls, with no difference noted between a 4.5 g daily and a 9 g daily dose of supplementation (Level 4 study).

Overall, based on the studies of arginine, there is moderate quality evidence supporting the positive effect of offering a high calorie, high protein nutritional supplement containing arginine and micronutrients to promote pressure ulcer healing.

Hydration

- 1. Provide and encourage adequate daily fluid intake for hydration for an individual assessed to be at risk of or with a pressure ulcer. This must be consistent with the individual's comorbid conditions and goals. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
- 2. Monitor individuals for signs and symptoms of dehydration including change in weight, skin turgor, urine output, elevated serum sodium, and/or calculated serum osmolality. (Strength of Evidence = C; Strength of Recommendation = 👍)**
- 3. Provide additional fluid for individuals with dehydration, elevated temperature, vomiting, profuse sweating, diarrhea, or heavily exuding wounds. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Fluid serves as the solvent for vitamins, minerals, glucose and other nutrients and transports nutrients and waste products through the body. In healthy individuals who are adequately hydrated, food accounts for 20% or more of total fluid intake.⁶³ Total fluid needs include the water content of food.⁶³ Oral nutritional supplements and enteral feedings are generally 75% water. For the specific amount of free fluids in each enteral formula, refer to each product's nutrition labeling. Additional free water may be required.

Health professionals should monitor individuals' hydration status, checking for signs and symptoms of dehydration such as: changes in weight, skin turgor, urine output, elevated serum sodium, or calculated serum osmolality.⁶⁴

Calculate individual fluid requirements. Various formulas have been used to calculate adequate daily fluid intake. Evidence-based guidelines recommend that fluid requirements be calculated as 1 mL/kcalorie consumed daily.^{30, 65} Individuals with elevated temperature, vomiting, profuse sweating, diarrhea, and/or heavily exuding wounds often require additional fluid intake to replace fluid loss.³⁰ Individuals consuming high levels of protein may also require additional fluid. Conduct ongoing reassessment for tolerance and changes in clinical condition.

Vitamins and Minerals

1. **Provide/encourage individuals assessed to be at risk of pressure ulcers to consume a balanced diet that includes good sources of vitamins and minerals. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
2. **Provide/encourage an individual assessed to be at risk of a pressure ulcer to take vitamin and mineral supplements when dietary intake is poor or deficiencies are confirmed or suspected. (Strength of Evidence = C; Strength of Recommendation = 👍)**
3. **Provide/encourage an individual with a pressure ulcer to consume a balanced diet that includes good sources of vitamins and minerals. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**
4. **Provide/encourage an individual with a pressure ulcer to take vitamin and mineral supplements when dietary intake is poor or deficiencies are confirmed or suspected. (Strength of Evidence = B; Strength of Recommendation = 👍)**

The National Academy of Sciences, Institute of Medicine, and Food and Nutrition Board Dietary Reference Intakes indicate the level of each micronutrient needed at each stage of life for healthy individuals.⁵⁵ Most nutrient needs can be met through a healthy diet. However, individuals who consume a diet low in nutrient rich foods, those who are food insecure (unable to purchase or prepare an adequate diet) or individuals with poor nutrient absorption or metabolism may not be consuming an adequate diet to meet established nutritional reference standards.^{66,67} Health professionals are advised to review the nutrition labeling on ONS, to determine micronutrient adequacy.

Micronutrients that are hypothesized to be related to pressure ulcer healing include Vitamin C (ascorbic acid), zinc, and copper. Vitamin C has a role in collagen formation and is an antioxidant; however, a double blinded RCT (n = 88) found no improvement in time to complete healing of pressure ulcers for adults supplemented with 1 g daily of Vitamin C compared to a control group receiving 10 mg Vitamin C daily for 12 weeks⁶⁸ (Level 1 study). The inclusion of fruits (particularly citrus fruit) and vegetables in the diet can achieve the desired recommended daily amount. However, Vitamin C at physiological doses should be considered when dietary deficiency is diagnosed.

Zinc and copper have also been hypothesized to affect wound healing. No research has demonstrated an effect of zinc supplementation on improved pressure ulcer healing. When clinical signs of zinc deficiency are present, zinc should be supplemented at no more than 40 mg of elemental zinc per day. Some health professionals recommend that this supplementation be given for 2 to 3 weeks, but more research is needed to substantiate this recommendation. High dose zinc supplementation (above 40 mg per day) can adversely affect copper status, possibly resulting in anemia. Good dietary sources of zinc include high protein foods such as meat, liver, and shellfish.

A small, prospective RCT by Theilla et al. (2012)⁶⁹ investigated the impact of a fish oil enriched formula on pressure ulcer healing. Adults requiring nutritional support for at least five days and who had a Category/Stage II or greater pressure ulcer were recruited from an intensive care unit in Israel (n = 40). The study participants received either enteral or parenteral nutrition containing fish oil and a micronutrient-enriched formula (enteral nutrition was enriched with vitamins A, C and E, zinc; manganese; copper and protein; study group, n = 20) or an isonitrogenous formula (control group, n = 20). Severity of pressure ulcers as assessed using PUSH scores significantly increased over time (p = 0.02) for the control group, while the study group had no significant change in PUSH scores. The study suggests that a micronutrient-enriched formula contributes to the prevention of worsening pressure ulcers.

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REPOSITIONING AND EARLY MOBILIZATION

Introduction

Repositioning and mobilizing individuals is an important component in the prevention of pressure ulcers.¹ The underlying cause and formation of pressure ulcers is multifaceted; however, by definition pressure ulcers cannot form without loading, or pressure, on tissue. Extended periods of lying or sitting on a particular part of the body and failure to redistribute the pressure on the body surface can result in sustained deformation of soft tissues and, ultimately, in ischemia and inevitable tissue damage² (see the *Etiology of Pressure Ulcers* section of the guideline).

Typically a painful stimulus caused by the pressure on the tissue will motivate the individual to change position. Therefore, two primary concerns are the individual's ability to feel pain, and the person's actual physical ability to move or reposition herself or himself.² Repositioning involves a change in position of the lying or seated individual undertaken at regular intervals, with the purpose of relieving or redistributing pressure and enhancing comfort. Mobilization involves assisting or encouraging a person to move or shift into a new position. Individuals who cannot reposition themselves will require assistance in this activity.

Recommendations in this section of the guideline address the role of repositioning and early mobilization in both the prevention and treatment of pressure ulcers. Repositioning in relation to heel pressure ulcers are discussed in a separate section of the guideline, *Repositioning to Prevent and Manage Heel Pressure Ulcers*. Recommendations on repositioning are also included in the sections of the guideline for *Special Populations*.

General Repositioning for All Individuals

- 1. Reposition all individuals at risk of, or with existing pressure ulcers, unless contra-indicated. (Strength of Evidence = A; Strength of Recommendation = 👍👍)**

Repositioning of an individual is undertaken to reduce the duration and magnitude of pressure over vulnerable areas of the body and to contribute to comfort, hygiene, dignity, and functional ability.

Three randomized controlled trials (RCTs) support this statement.²⁻⁴ Defloor et al. (2005)² conducted a RCT involving 838 nursing home residents at risk for pressure ulcers. The study found that turning a patient every four hours on a viscoelastic mattress resulted in a significant reduction in the incidence of Category/Stage II and more severe pressure ulcers, and in the time to pressure ulcer development, compared to the usual care in the facility at the time the study was conducted (water mattresses, alternating mattresses, sheepskins or gel cushions; repositioning was not part of the local standard care) (odds ratio [OR] = 0.12; 95% confidence interval [CI] 0.03 to 0.48). The time spent implementing the repositioning in the intervention group could have impacted upon the care of the individuals in the control group. (Level 1 study).

Vanderwee et al. (2007)³ also performed a RCT in nursing homes, following 235 residents who were all provided with a viscoelastic foam mattress. In the experimental group, patients were repositioned to alternate two hours in a lateral position and four hours in a supine position; in the control group, patients were repositioned every four hours, first in lateral and then in supine position. This study reported that the group lying for a shorter time in the lateral position on a pressure redistributing mattress did not have fewer pressure ulcers (at least Category/Stage II pressure ulcers; $p = 0.40$). However, the study did not recruit sufficient participants to meet the desired power (Level 2 study)

The third study was conducted by Moore et al. (2011)⁴ among older adults in 12 aged care facilities ($n = 213$). In the experimental group participants were repositioned every three hours using the 30° tilt (left side, back, right side back) between 8pm and 8am ($n = 99$ participants). In the control group participants received routine repositioning every six hours using a 90° lateral rotation between 8pm and 8am ($n = 114$ participants). Day time care remained routine for all facilities. Fewer participants in the

experimental group developed a pressure ulcer (3% versus 11%; $p = 0.03$, intraclass correlation [ICC] = 0.001); incidence rate ratio [IRR] = 0.27 (95% CI 0.08 to 0.93, $p = 0.038$, ICC = 0.001); the OR of a pressure ulcer in the experimental group was 0.243 (95% CI 0.067 to 0.879, $p = 0.034$). The frequency of turning in the control group was six hourly, which may not be considered as standard care in many facilities. (Level 2 study).

2. **Consider the condition of the individual and the pressure redistribution support surface in use when deciding if repositioning should be implemented as a prevention strategy. (Strength of Evidence = C; Strength of Recommendation = 👉)**

This statement is based on expert opinion. Regular positioning is not possible for some individuals because of their medical condition, and an alternative prevention strategy such as providing a high-specification mattress or bed may need to be considered.

For a limited number of medical conditions where movement destabilizes the condition of critically ill patients, it may not be safe to turn the individual.⁵ The guideline sections *Special Populations: Critically Ill Individuals* and *Special Populations: Individuals In Palliative Care* contain recommendations and discussion addressing individuals for whom medical condition or care preferences preclude regular repositioning.

Repositioning Frequency

1. **Consider the pressure redistribution support surface in use when determining the frequency of repositioning. (Strength of Evidence = A; Strength of Recommendation = 👉)**

Defloor et al. (2005)² found that turning an individual every four hours on viscoelastic foam mattresses resulted in statistically fewer pressure ulcers (at least Category/Stage II pressure ulcers) compared to turning every two or three hours on a non-pressure redistributing mattress (OR = 0.12; 95% CI 0.03 to 0.48) (Level 1 study).

2. **Determine repositioning frequency with consideration to the individual's:**

- tissue tolerance,
- level of activity and mobility,
- general medical condition,
- overall treatment objectives,
- skin condition, and
- comfort. (Strength of Evidence = C; Strength of Recommendation = 👉👉)

When planning an individual's repositioning schedule, it is important to first assess his or her risk of pressure ulcers, paying particular attention to level of activity and mobility, as those with reduced activity and mobility are more prone to pressure ulcer damage. It is also important to take into consideration the individual's overall treatment objectives. For example, certain medical conditions, such as respiratory or cardiac disorders, may mean that the individual becomes very dyspneic or hemodynamically unstable unless cared for in a particular position.

One study⁶ investigated the association between repositioning frequency and pressure ulcer incidence. In this study "frequently repositioned" amounted to at least 12 repositions per day over the study period of 21 days. For participants with a high pressure ulcer risk based on Braden score, there was a lower incidence of pressure ulcers among those who were frequently turned (IRR = 0.39, 95% CI 0.08 to 1.84). The investigators relied upon nursing documentation as the sole indicator that an individual had been repositioned (level 3 study).

Still et al. (2013)⁷ reported on a quality improvement initiative in which a "turn team" was introduced to a surgical intensive care unit (ICU). Nurses and patient care attendants (PCAs) received online education on pressure ulcer prevention and risk assessment. After education on turn mechanics, a team

of two PCAs was responsible for repositioning hemodynamically stable individuals every two hours, unless the nurse identified contraindications. The pressure ulcer prevalence in the ICU, assessed by a wound specialist using the NPUAP staging system, decreased from a mean 15.1% prior to the intervention to a mean 5.2% ($p < 0.0001$) following the intervention introduction. It was unclear if patients actually received more frequent repositioning, as the protocol allowed for nurses to request individuals not be turned. The pre-intervention audit period was two years (15 audits) but the post audit period was limited to 15 weeks (15 audits). Hawthorne effect associated with increased audit frequency may have influenced the findings (Level 5 study).

Pompeo (2013)⁸ investigated the use of a pressure mapping device for prompting staff to reposition patients. The pressure map was placed under individuals at high risk of pressure ulcers (Braden scale ≤ 12) and relayed pressure images to a monitor. An alarm sounded in the nurses' station at a time interval set by the facility (in this study, every two hours). When reinforced by regular education and mandatory staff meetings, the system increased frequency of repositioning from a mean of 240 minutes to a mean of 164 minutes. The study did not report the intervention's influence on pressure ulcers (indirect evidence). Further research is required before routine use of pressure mapping systems could be recommended. Numerous pressure ulcer prevention programs have successfully utilized facility-wide audible cues to prompt staff to reposition individuals at regular intervals (see *Implementing the Guideline: Facilitators, Barriers and Implementation Strategy* section of the guideline).

3. Establish pressure relief schedules that prescribe the frequency and duration of weight shifts. (Strength of Evidence = C; Strength of Recommendation = 👍)

3.1. Teach individuals to do 'pressure relief lifts' or other pressure relieving maneuvers as appropriate. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

These statements are based on expert opinion. For further discussion on pressure relief lifts, see the *Special Populations: Individuals with Spinal Cord Injury* section of the guideline.

4. Regularly assess the individual's skin condition and general comfort. Reconsider the frequency and method of repositioning if the individual is not responding as expected to the repositioning regime. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Frequent assessment of the individual's skin condition will help to identify the early signs of pressure damage and, as such, her/his tolerance of the planned repositioning schedule. If changes in skin condition should occur, the repositioning care plan needs to be re-evaluated.

Repositioning Techniques

1. Reposition the individual in such a way that pressure is relieved or redistributed. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

When choosing a particular position for the individual, it is important to assess whether the pressure is actually relieved or redistributed. For example, it is possible to inadvertently place the individual in a position such that smaller areas of the body, such as the heels, are continuously exposed to pressure.

A descriptive comparative study⁹ investigated the effect of positioning on tissue blood flow and skin temperature in six different lying positions (supine tilt 30°; supine 0°; semi-fowler with elevated head 30°; semi-fowler with elevated head and legs 30°; lateral 30° and lateral 90°) among 20 older hospitalized individuals. The median relative change in superficial blood flow over bony prominences increased in all supine positions and decreased in the lateral positions (indirect evidence).

Assessment of the individual's skin condition will indicate areas of the body that are exposed to sustained pressure.

2. **Avoid positioning the individual on bony prominences with existing non-blanchable erythema. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Non-blanchable erythema is an indication of the early signs of pressure ulcer damage. If an individual is positioned directly onto bony prominences with pre-existing non-blanchable erythema, the pressure and/or shearing forces sustained will further occlude blood supply to the skin, thereby worsening the damage and resulting in more severe pressure ulceration. The guideline section *Skin and Tissue Assessment* discusses differentiation of erythema.

3. **Avoid subjecting the skin to pressure and shear forces. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

- 3.1. **Use manual handling aids to reduce friction and shear. Lift — don't drag — the individual while repositioning. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

In most situations simple techniques like lift sheets can be used. Principles of safe manual handling should be used to ensure safety of both the individual and the health professional.

A cross-sectional survey of 271 long term care facilities reported a significantly lower prevalence of pressure ulcers in individuals at high risk in facilities with more than eight powered mechanical lifting (PML) aids compared with facilities that had four or less PML aids (14.94% versus 9.74%, $p = 0.00$). Methodological limitations of the study included self-selection of participating facilities and reliance on self-reported data¹⁰ (Level 5 study).

- 3.2. **Use a split leg sling mechanical lift when available to transfer an individual into a wheelchair or bedside chair when the individual needs total assistance to transfer. Remove the sling immediately after transfer. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Prolonged sitting on a transfer sling may increase heat, moisture and pressure. Sling material may interfere with pressure redistributing qualities of a support surface.

- 3.3. **Do not leave moving and handling equipment under the individual after use, unless the equipment is specifically designed for this purpose. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Pressure ulcers occur because of sustained mechanical loading and shearing forces. Therefore, in order to prevent pressure ulcers, the skin should not be exposed to pressure and shear forces.

Individuals should never be dragged across any surface during transfer or repositioning. Rather, use devices and techniques that reduce tissue damage due to friction and shear. These include mechanical lifts, transfer sheets, 2- to 4-person lifts, and turn-assist features on beds. Moving and handling equipment may create areas of localized pressure resulting in additional tissue damage¹ but should not remain under the individual after use, unless the equipment has been specifically designed for this purpose (e.g. low friction textiles, as discussed in the *Emerging Therapies for Prevention of Pressure Ulcers* section of the guideline).

4. **Avoid positioning the individual directly onto medical devices, such as tubes, drainage systems or other foreign objects. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. It is possible to inadvertently position an individual directly on top of a tube, drainage system or other foreign object (e.g. eating utensils, remote controls). This will cause a localized area of pressure that, if not corrected early enough, will result in development of a pressure ulcer. Therefore, before leaving individuals following repositioning, it is important to check that they are not lying directly on a medical device or foreign object. The *Medical Device Associated Pressure*

Ulcers section of the guideline includes comprehensive recommendations on preventing device related pressure ulcers through appropriate positioning of the device and the individual.

5. **Do not leave the individual on a bedpan longer than necessary. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Repositioning Individuals in Bed

1. **Use the 30° tilted side-lying position (alternately, right side, back, left side) or the prone position if the individual can tolerate this and her/his medical condition allows. (Strength of Evidence = C; Strength of Recommendation = 👍)**
 - 1.1. **Encourage individuals who can reposition themselves to sleep in a 30° to 40° side-lying position or flat in bed if not contraindicated. (Strength of Evidence = C; Strength of Recommendation = 👍)**
 - 1.2. **Avoid lying postures that increase pressure, such as the 90° side-lying position, or the semi-recumbent position. (Strength of Evidence = C; Strength of Recommendation = 👍)**

One laboratory study explored interface pressure measurements on 83 healthy volunteers after one hour of immobilization in 10 different positions, on two mattresses.¹¹ The 30° position (see Figure 1) and the prone position resulted in the lowest interface pressure measurements. The 30° side laterally inclined position (see Figure 2) gave lower readings than the 90° side-lying position. Defloor (2000)¹¹ concluded that the 90° side-lying position gave the highest interface pressure measurements (indirect evidence).

A further descriptive comparative study by Källman et al. (2013)⁹ investigated the effect of positioning on tissue blood flow and skin temperature in six different lying positions (supine tilt 30°; supine 0°; semi-fowler with elevated head 30°; semi-fowler with elevated head and legs 30°; lateral 30° and lateral 90°) among 20 hospitalized older persons. The median relative change while positioned in the lateral 30° position was significantly lower than in all the supine positions ($p < 0.05$). The median relative change of blood flow in the lateral 90° position was also lower in comparison with the supine tilt 30° position ($p = 0.012$) (indirect evidence)

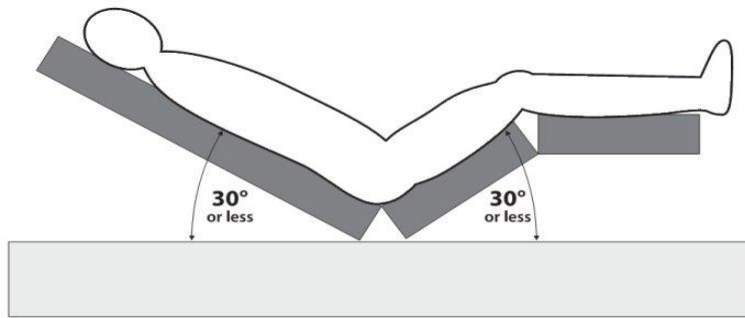
Figure 1: Lateral 30° position



2. **Limit head-of-bed elevation to 30° for an individual on bedrest unless contraindicated by medical condition or feeding and digestive considerations. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Pressure and shear are reduced when the head-of-bed is elevated at less than 30°. ¹¹⁻¹⁵

Figure 2: 30° position




Chung et al. (2012)¹⁵ investigated changes in interface pressure at the sacrum and tuberosities associated with raising the head-of-bed. Participants ($n = 42$) were immobile, in long term care, and at high risk of pressure ulcers. Sacral and tuberosity interface pressures were significantly greater (all $p < 0.001$) with the head-of-bed elevated at 30°, 45° and 60° compared with 0°. Elevation of the

head-of-bed to 15° resulted in a non-significant increase in sacral and tuberosity interface pressure (indirect evidence). Peterson et al. (2008)¹⁶ conducted a laboratory study on 15 health volunteers investigating interface pressure associated with head-of-bed elevation. There was a significant increase in interface pressures associated with raising the head-of-bed to 30° when the individual was positioned in the 30° lateral position using pillows or wedges ($p < 0.05$) (indirect evidence).


Best et al. (2012)¹⁷ conducted a study in healthy, community-dwelling individuals classified as having a low risk of pressure ulcers ($n = 117$) on a low technology trunk release maneuver. A comparison of the sacral peak pressure index (interface pressure) and discomfort rated by the individual was made between positioning in a high Fowler's position and positioning with the use of the trunk release maneuver (the individual's trunk was pulled forward and away from the support surface without lifting the buttocks from the support surface). There was a significant reduction in the peak pressure index associated with use of the trunk release maneuver (59.6 mmHg versus 79.9 mmHg, $p = 0.002$) and no differences in perceived discomfort between the groups. Using the trunk release maneuver may reduce interface pressure for individuals sitting upright in bed (indirect evidence).

Elevating the head of the bed may be medically necessary to facilitate breathing and/or prevent aspiration and ventilator associated pneumonia. In these cases, semi-Fowler's position is preferred.¹¹ Individuals should be positioned and supported to prevent sliding down in bed and creating shear forces.

2.1. If sitting in bed is necessary, avoid head-of-bed elevation or a slouched position that places pressure and shear on the sacrum and coccyx. (Strength of Evidence = C; Strength of Recommendation = )

This statement is based on expert opinion. The maximum head-of-bed elevation in standard hospital beds ranges from 55° to 80°. Sitting time should be limited according to the individual's skin tolerance and medical status. In supine position with the head-of-bed elevated, the sacrum is subjected to shear stress/strain and pressure. A reclined or slouched posture should be avoided, as this causes weight bearing and shear on the sacrum and/or coccyx. Flexing the knees and positioning with pillows under the arms may prevent some sliding and slouching when the head-of-bed is elevated. Individuals with pressure ulcers on the sacrum and/or coccyx may prefer to sit erect on the side of the bed while eating. Some integrated bed systems transform into a chair position; if such a bed is used, ensure that pressure is not placed directly on the ulcer in this position, and place pillows under the arms to prevent slouching and sliding.

Prone Position

1. Use a pressure redistribution surface to offload pressure points on the face and body while in the prone position. (Strength of evidence = C; Strength of Recommendation = )

2. **At each rotation, assess other body areas (i.e., breast region, knees, toes, penis, clavicles, iliac crest, symphysis pubis) that may be at risk when individuals are in the prone position. (Strength of evidence = C; Strength of Recommendation = 👍)**
3. **At each rotation, assess individuals placed in the prone position for evidence of facial pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Individuals placed in the prone position may be at increased risk for the development of facial pressure ulcers. In one small case series report (n = 15) conducted in a critical care setting, 13% (2/15) of participants with severe acute respiratory distress syndrome who were positioned in a prone position for ventilation (mean time in prone position 55 ± 7 hours) developed a Stage II pressure ulcer on the face.¹⁸

Further research on prone positioning conducting in operating room settings provides guidance on preventing facial and chest pressure ulcers (see *Special Populations: Individuals in the Operating Room*). Additional discussion of prone positioning is included in the guideline section *Special Populations: Critically Ill Individuals*.

Repositioning Seated Individuals

1. **Position the individual so as to maintain stability and his or her full range of activities. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Repositioning so as to allow stability and full range of activities may be a complex process. For example, in an armchair that tilts back, the use of a footrest with the heels offloaded may be a suitable position in terms of pressure redistribution, but may impede transfer to and from the chair.

2. **Select a seated posture that is acceptable for the individual and minimizes the pressures and shear exerted on the skin and soft tissues. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Pressure and shear forces are important considerations in the development of pressure ulcers in seated individuals.

- 2.1. **Provide adequate seat tilt to prevent sliding forward in the wheelchair or chair, and adjust footrests and armrests to maintain proper posture and pressure redistribution. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion and indirect evidence. The ischia bear intense pressure when the individual is seated. Pressure remains unrelieved when the individual is paralyzed because small involuntary movements that restore blood flow to the tissues are absent. Therefore, a support surface that provides adequate pressure redistribution is required so that daily and other activities can be completed without subjecting the ulcer to pressure that could delay healing.

A repeated measures study¹⁹ systematically measured the relative reduction in interface pressure at the ischial tuberosities and sacrum through 10° increments of tilt in a manual wheelchair for individuals with motor complete spinal cord injury (SCI). A reduction in sacral pressure did not occur until a 30° tilt. A minimum tilt of 30° is needed to achieve a clinically important reduction in pressure at the ischial tuberosities (indirect evidence).

3. **Ensure that the feet are properly supported either directly on the floor, on a footstool, or on footrests when sitting (upright) in a bedside chair or wheelchair. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Maintenance of proper positioning and postural control is important. When the feet do not rest on the floor, the body slides forward out of the chair. Defloor et al. (1999)²⁰ established that seated pressure is significantly lower ($p < 0.001$) when the feet of a patient seated in an upright position are on the ground compared with supporting the legs with a rest. Having the feet unsupported may also cause excessive pressure behind the knee, impeding circulation. An armchair helps maintain posture and is associated with lower pressure than an armless chair (see *Figure 3*).²⁰

To avoid shear and friction select a seat with an appropriate seat-to-floor height for the individual. If the individual's feet cannot be positioned directly on the ground, footrest height should be adjusted so as to slightly tilt the pelvis forward by positioning the thighs slightly lower than horizontally. This position transfers weight (e.g., load) of the upper body onto the posterior thigh. When the footrest is too high, the load is applied to the posterior pelvic region, placing the stress back onto the ischia and coccyx, which may add stress to the feet. Seat depth should be sufficient to allow maximum pressure redistribution over the thighs²⁰ (indirect evidence). See *Figure 3* and *Figure 4* from Defloor et al. (1999)²⁰ (indirect evidence).

Figure 3: Sitting upright in an armchair with the feet on the ground

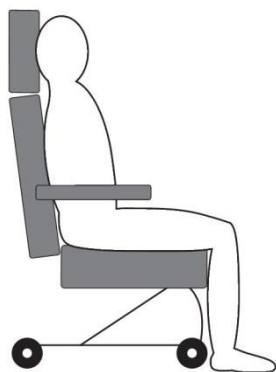
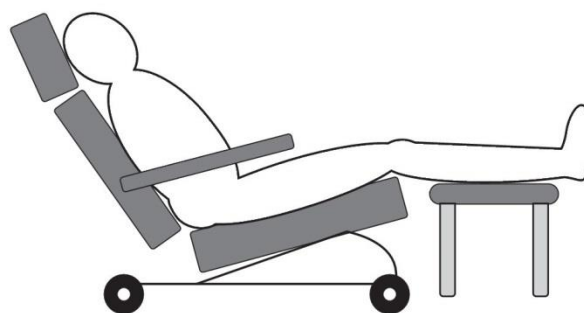


Figure 4: Sitting back in an armchair with the lower legs on a rest



3.1. Avoid the use of elevating leg rests if the individual has inadequate hamstring length. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based on expert opinion. The hamstring muscle crosses the knee and hip joint. If the hamstring length is inadequate and elevating leg rests are used, the pelvis will be pulled into a sacral sitting posture, causing increased pressure on the coccyx and/or sacrum.

4. Limit the time an individual spends seated in a chair without pressure relief. (Strength of Evidence = B; Strength of Recommendation = 👍👍)

Gebhardt et al. (1994)²¹ investigated in a small crossover study the effect of a sitting protocol restricted to two hours per session. Fifty-seven participants who either had a fracture or had recently had major orthopedic surgery were recruited from two wards. All participants were placed on large-celled alternating mattress. Significantly fewer pressure ulcers (7%) developed in individuals with fractures who were allowed to sit for two hours or less per session than in those allowed to sit in a chair for unlimited periods (63%) ($p < 0.001$) (Level 2 study).

Additional Recommendations for Individuals with Existing Pressure Ulcers

1. Do not position an individual directly on a pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍)

- 1.1. **Position the individual off area(s) of suspected deep tissue injury with intact skin. If pressure over the area cannot be relieved by repositioning, select an appropriate support surface. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Pressure reduces perfusion to injured tissues. Continued pressure on an existing pressure ulcer will delay healing and may cause additional deterioration. In situations where positioning on the pressure ulcer cannot be avoided (e.g., when the individual has multiple ulcers on multiple surfaces), limit the amount of time the individual is positioned on the ulcer, change support surfaces to provide better pressure redistribution, and use positioning techniques that redistribute pressure off of the ulcer as much as possible (e.g., use specially designed contour seating surfaces or ‘bridging’ areas around the ulcer with positioning devices that offload the ulcer area and redistribute pressure to surrounding tissue).

2. **Continue to turn and reposition the individual regardless of the support surface in use. Establish turning frequency based on the characteristics of the support surface and the individual’s response. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. No support surface provides complete pressure relief. Pressure is always applied to some area of the skin. Turning and repositioning for pressure redistribution must occur regularly. The frequency of turning may vary with the pressure redistribution capacity of the support surface. The individual’s response to pressure should also guide turning frequency. High risk individuals with poor tissue tolerance may require more frequent turning. Turning schedules should be individualized based on tissue tolerance, patient rights, and the specific surface being used.

3. **Inspect the skin for additional damage each time the individual is turned or repositioned. Do not turn the individual onto a body surface that is damaged or still reddened from a previous episode of pressure loading, especially if the area of redness does not blanch (i.e., Category/Stage I pressure ulcer). (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Ongoing assessment of the skin is necessary in order to detect additional skin damage. Skin that is still reddened from a previous episode of loading may be damaged and undergoing an inflammatory response, or may still be in the process of reperfusing tissues. Slower and/or diminished reactive hyperemic responses have been demonstrated in individuals at risk of pressure ulcers such as the elderly,²²⁻²⁴ critically ill individuals,²⁵ smokers,²⁶ individuals with diabetes mellitus,²⁷⁻²⁹ and individuals with SCI.³⁰⁻³³ The rate of reperfusion is slower after the area is unloaded, and reperfusion may ultimately be inadequate to offset the oxygen debt created during periods of loading. These individuals may require longer ‘recovery time’ before reloading a body surface and/or a support surface with better pressure redistribution.

Repositioning the Individual with Existing Pressure Ulcers in a Chair

1. **Minimize seating time and consult a seating specialist if pressure ulcers worsen on the seating surface selected. (Strength of Evidence = C; Strength of Recommendation = 👍)**
2. **Consider periods of bed rest to promote ischial and sacral ulcer healing. (Strength of Evidence = C; Strength of Recommendation = 👍)**
 - 2.1. **Weigh the risks and benefits of supported sitting against benefits to both physical and emotional health. (Strength of Evidence = C; Strength of Recommendation = 👍)**

These statements are based on expert opinion. Further discussion on the risks and benefits of supported seating for individuals with an existing ischial or sacral pressure ulcer is included in the guideline section *Special Populations: Individuals with Spinal Cord Injury*.

- 3. If sitting in a chair is necessary for individuals with pressure ulcers on the sacrum/coccyx or ischia, limit sitting to three times a day in periods of 60 minutes or less. Consult a seating specialist to prescribe an appropriate seating surface and/or positioning techniques to avoid or minimize pressure on the ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Sitting is important to reducing the hazards of immobility, facilitating eating and breathing, and promoting rehabilitation. While sitting is important for overall health, every effort should be made to avoid or minimize pressure on the ulcer. Sitting applies pressure to the sacrum when the individual does not sit erect (i.e., slouches). When individuals sit erect, pressure is applied to the ischia. Because any intense pressure reduces blood flow and impairs healing, time must be limited to one hour three times daily; the sitting time should correspond to meal time. Sitting times can be increased or decreased based on the improvement or deterioration of the ulcer. Periodic shifting, tilting forward, or lift-offs while sitting may facilitate some reperfusion.

- 4. Avoid seating an individual with an ischial ulcer in a fully erect posture (in chair or bed). (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. The ischia bear intense pressure when the individual is seated. Therefore, seating cushions must be high-immersion uniform-loading distribution cushions or be equipped with a pressure redistribution contour. A slight tilt of the pelvis may limit ischial pressure.²⁰

- 5. Modify sitting time schedules and re-evaluate the seating surface and the individual's posture if the ulcer worsens or fails to improve. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Tolerance of pressure varies in each individual. Sitting increases pressure on the ulcer, generally leading to wound deterioration or failure to improve. Seating surfaces not functioning at their expected level of performance should be re-evaluated and replaced. Better postural control may also decrease pressure on the ulcer.

Positioning Devices

- 1. Do not use ring or donut-shaped devices. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. The edges of these devices create areas of high pressure that may damage tissue. A constrictive edge may also impair circulation and create edema^{12, 34}.

- 2. The following 'devices' should not be used to elevate heels:**

- synthetic sheepskin pads;
- cutout, ring, or donut-type devices;
- intravenous fluid bags; and
- water-filled gloves. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

All these products have been shown to have limitations. For example, synthetic sheepskin becomes knotted following washing, and the knots cause pressure; ring or donut devices cause ischemia over the pressure area; and water-filled gloves have been used under individuals' heels, but when the individual moves, the heels move off the gloves. Intravenous fluid bags were associated with significantly more heel ulcers when compared with a heel suspension boot (0 versus 40%, $p = 0.006$)³⁵ (Level 3 study).

- 3. Natural sheepskin pads might assist in preventing pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = 👍)**

Jolley et al. (2004)³⁶ reported a RCT ($n = 441$) involving participants at low to moderate risk for pressure ulcer development, comparing the use of an Australian medical sheepskin with standard nursing care (any pressure redistributing strategy decided by a nurse). The pressure ulcer incidence was 9.6% in the

intervention group, compared with 16.6% in the control. The relative risk was 0.58 (95% CI 0.35 to 0.96). However, these results should be treated with caution, as there were numerous methodological flaws, and there is a high risk of bias (Level 2 study).

McGowan et al. (2000)³⁷ performed a RCT involving 297 individuals in orthopedic care. The experimental group (n = 155) had both an Australian medical sheepskin and a standard hospital mattress, and the control group (n = 142) had a standard hospital mattress with or without other low-technology constant pressure supports. The pressure ulcer incidence in the control group was 30.3% and 9% in the experimental group (p < 0.0001). Some methodological flaws should be recognized (Level 2 study).

Mobilization

1. **Develop a schedule for progressive sitting according to the individual's tolerance and pressure ulcer response. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Additional recommendations and discussion on schedules for progressive seating are included in the guideline section *Special Populations: Individuals with Spinal Cord Injury*.

2. **Increase activity as rapidly as tolerated. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Individuals on bedrest should progress to sitting and ambulation as rapidly as they can tolerate. Ambulation schedules may help offset the clinical deterioration often seen in patients subjected to prolonged bedrest. Scheduled periods of ambulation (or supported standing when ambulation is not possible) may be viable alternatives to complete bedrest for individuals with ischial and sacral ulcers who cannot tolerate sitting.

One team of researchers reported on an intervention to increase mobilization in surgical intensive care patients. The intervention, which was facilitated by the employment of an additional health professional and delivery of education sessions, provided a protocol of increased mobilization from passive range of movement exercises, to dangling limbs over the side of the bed, sitting out of bed, standing and walking (all three times per day). Three months following the introduction of the intervention the ICU reported a significant increase in facility-acquired pressure ulcers (6.1% versus 5.45% p = 0.009, adjusting for length of stay). The intervention was also associated with an increased length of stay in both the unit (p < 0.001) and the hospital (p = 0.002). The researchers reported that the increase in pressure ulcers may have been related to an increase in patient acuity. Although there was no significant difference in Acute Physiology and Chronic Health Evaluation (APACHE) scores between the two cohorts, the post-implementation cohort had a significantly higher risk of pressure ulcers as determined by Braden scores (15.66 versus 15.24, p < 0.001). The intervention promoted raising the head-of-bed to 30° to 45°, which may also have contributed to the increase in pressure ulcers (Level 3 study).³⁸⁻⁴⁰

Repositioning Documentation

1. **Record repositioning regimes, specifying frequency and position adopted, and include an evaluation of the outcome of the repositioning regime. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Documentation provides a written record of care delivery and, as such, serves as evidence that repositioning has occurred. It is therefore important to record each repositioning episode and to include a record of the individual's skin condition as an indicator of tolerance of that particular positioning plan.

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REPOSITIONING TO PREVENT AND TREAT HEEL PRESSURE ULCERS

Introduction

The reduction of pressure and shear at the heel is an important point of interest in clinical practice. In a European survey on pressure ulcer prevalence (n = 5,947), an individual's most severe pressure ulcer was typically found at the sacrum (44.8%) or the heels (24.2%).¹ In the same study, almost 80% of all Category/Stage IV pressure ulcers were found at the sacrum and heels (39.9% and 38.5%, respectively).

The posterior prominence of the heel sustains intense pressure, even when a pressure redistribution surface is used. Because the heel is covered with a small volume of subcutaneous tissue, mechanical loads are transmitted directly angular to the bone. Given the small surface area of the heel, it is challenging to try to redistribute load from the heel through the use of pressure redistributing devices.

These recommendations should be considered in addition to the general repositioning recommendations in the guideline section *Repositioning and Early Mobilization*. Prevention of heel pressure ulcers is also addressed in the section specific to individuals undergoing surgery in the section *Special Population: Individuals in the Operating Room*.

General Recommendations

1. **Inspect the skin of the heels regularly. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. The guideline section *Skin and Tissue Assessment* contains comprehensive discussion and recommendation on assessing the skin.

Repositioning for Preventing Heel Pressure Ulcers

1. **Ensure that the heels are free of the surface of the bed. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Ideally, heels should be free of all pressure — a state sometimes called 'floating heels'. Pressure can be relieved by elevating the lower leg and calf from the mattress by placing a pillow under the lower legs, or by using a heel suspension device that floats the heel. Consequently, the pressure will instead spread to the lower legs, and the heels will no longer be subjected to pressure.

- 1.1. **Use heel suspension devices that elevate and offload the heel completely in such a way as to distribute the weight of the leg along the calf without placing pressure on the Achilles tendon. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

Heel suspension devices are preferable for long term use, or for individuals who are not likely to keep their legs on the pillows. Heel suspension devices vary in design and their selection should be based upon the individual's clinical condition, the plan of care, the individual's tolerance of the device, and the manufacturer's guidelines. Some are not appropriate to be worn in bed due to risks of pressure ulcer formation on other parts of the leg — particularly if the boot has metal support bars on the sides, if the individual has contractures, or if the individual has reduced sensation or ability to communicate points of pressure.

Donnelly et al. (2011)² conducted a randomized controlled trial (RCT) comparing complete offloading of the heel using a commercial heel suspension device to standard care (without heel offloading) for prevention of heel pressure ulcers. The researchers recruited 239 patients aged over 65 years who were admitted to a fracture trauma unit with hip fractures that occurred within the previous 48 hours. Subjects were excluded if they had an existing or previous pressure ulcer. Both the control group (n = 119 with 3 withdrawals) and intervention group (n = 120 with 9 withdrawals) received pressure redistributing support surfaces that included cut foam and

alternating pressure mattresses or mattress overlays. The primary outcome of interest was the occurrence of a new Category/Stage I or greater pressure ulcer on heels or other sites. The intervention group had significantly fewer pressure ulcers at any anatomical site than the control group (7% vs 26%, $p < 0.001$) and developed no pressure ulcers on the ankles, feet or heels, compared to 29 occurrences in the control group ($p < 0.001$). Kaplan-Meier survival curves indicated subjects in the control group were more likely to suffer pressure damage at all points in time (log rank, $p = 0.001$) and sensitivity analysis showed that when individuals lost to follow-up were assigned to the pressure ulcer outcome, the intervention group was still less likely to develop a pressure ulcer than those in the control group ($p = 0.0001$). The hazard analysis indicated that when considering the effect of multiple clinical and pathological factors that might be specific risk factors, participants randomized to the treatment group were five time less likely to develop pressure damage (hazard ratio = 0.21, 95% confidence interval [CI] 0.008 to 0.54) than the control group (hazard ratio = 1.00). There are some limitations to this study given the frequent protocol violations in relation to support surface upgrades by the nursing staff (Level 2 study).

Two studies of lower quality^{3,4} while weak, provide additional support to the recommendation. Bales (2012)⁴ demonstrated that a heel suspension boot was associated with significantly fewer pressure ulcers than use of intravenous bags for elevating the heels (0 versus 40%, $p = 0.006$) (Level 3 study) and Meyers (2010)³ reported a 55% reduction in “abnormal heels” between admission and discharge for individuals wearing a heel suspension boot (Level 5 study).

2. The knee should be in slight (5° to 10°) flexion. (Strength of Evidence = C; Strength of Recommendation = 👍)

There is indirect evidence that hyperextension of the knee may cause obstruction of the popliteal vein, and this could predispose an individual to deep vein thrombosis (DVT). Huber et al. (2009)⁵ studied the popliteal veins of 50 individuals under general anesthesia using heel elevators. Using duplex ultrasonography to examine the incidence of popliteal vein compression when the knees were flexed and extended, they found a significant reduction in popliteal vein diameter in extension compared with the diameter in flexion ($p < 0.001$).

3. Avoid areas of high pressure, especially under the Achilles tendon. (Strength of Evidence = C; Strength of Recommendation = 👍)

3.1. Use a foam cushion under the full length of the calves to elevate heels. (Strength of Evidence = B; Strength of Recommendation = 👍)

In a RCT, Cadue et al. (2008)⁶ evaluated the efficacy of placing a foam cushion under the legs to ‘float’ the heels free from the bed surface. Seventy individuals in intensive care were recruited, with half receiving a foam cushion and the remainder receiving no intervention at the heels. Fewer heel pressure ulcers developed among the group with the foam cushions (8.5% compared with 54.2% in the control group). There was also a longer heel-pressure-ulcer-free time in the group who used the foam cushions under their legs (time to development of heel pressure ulcers was 5.6 days in the foam cushion group and 2.8 days in the control group). This small study suggests the value of removing all pressure from the heels, but its interpretation is constrained by its lack of a formal power calculation and uncertain subject selection criteria (Level 2 study).

Pillows placed under the full length of the calves to elevate heels are also appropriate for short-term use in alert and cooperative individuals. Pillows or foam cushions used for heel elevation should extend the length of the calf to avoid areas of high pressure, particularly under the Achilles tendon. Flex the knee slightly to avoid popliteal vein compression and increased risk of DVT.

4. Apply heel suspension devices according to the manufacturer’s instructions. (Strength of Evidence = C; Strength of Recommendation = 👍)

ULCERS

This statement is based on expert opinion. Heel suspension devices should be applied so as to avoid creating areas of increased pressure under the device. Ensure that the heel suspension device is not too tight and does not create additional pressure damage.

- 5. Remove the heel suspension device periodically to assess skin integrity. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. The skin under the device should be checked routinely for device related pressure damage. Check the skin more frequently and loosen the device in individuals with, or likely to develop, lower extremity edema and individuals with neuropathy and peripheral arterial disease.

Repositioning for Treating Existing Heel Pressure Ulcers

- 1. Relieve pressure under the heel(s) with Category/Stage I or II pressure ulcers by placing legs on a pillow to ‘float the heels’ off the bed or by using heel suspension devices. (Strength of Evidence = B; Strength of Recommendation = 👍)**

Cheneworth et al. (1994)⁷ conducted a modified RCT study comparing the outcomes of Category/Stage I pressure ulcers on the heels between gauze dressings wrapped around the heel and a heel suspension boot. Healing and stabilization of the heel ulcer was seen in 13 of 14 subjects wearing the heel suspension device, while five ulcers deteriorated and five remained the same in the gauze dressing group (Level 2 study). Once an ulcer develops, pressure relief on the heel is needed to promote perfusion. Huber et al. (2008)⁸ documented significant increases in laser Doppler flow with heel elevation in normal subjects and subjects with peripheral vascular disease.

- 2. For Category/Stage III, IV and unstageable pressure ulcers, place the leg in a device that elevates the heel from the surface of the bed, completely offloading the pressure ulcer. Consider a device that also prevents footdrop. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Pressure on Category/Stage III, IV, and unstageable heel pressure ulcers should be completely offloaded as much as possible. Elevation of the heel on a pillow is usually inadequate. Due to the time required for healing deeper ulcers, a device that completely offloads the ulcer area and prevents footdrop is preferred.

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SUPPORT SURFACES

Introduction

Support surfaces are “specialized devices for pressure redistribution designed for management of tissue loads, microclimate, and/or other therapeutic functions (i.e., any mattress, integrated bed system, mattress replacement, overlay, or seat cushion, or seat cushion overlay)”.¹ In this context, pressure refers to distribution of forces on the individual’s body surface that is in contact with the device. As a person immerses (sinks) into the support surface, their weight can become distributed over a larger area. If the surface also envelops (i.e. conforms to the shape of) the person, the pressure on the individual’s body will become more evenly distributed and less concentrated over bony prominences where pressure ulcers typically develop. In practice, as a person lies or sits on a support surface their weight causes both the support surface and their own soft tissue to deform. The extent to which pressure is concentrated over small areas will determine the degree of potentially damaging deformation. A **reactive support surface** is a powered or non-powered support surface with the ability to change its load distribution properties only in response to an applied load. An **active support surface** is a powered support surface that produces alternating pressure through mechanical means and has the ability to change its load distribution properties with or without an applied load.²

Support surfaces are typically constructed from a range or combination of materials including **foam, gel** and **fluid**, and structures (i.e., bladders and modules that may be arranged in **zones** corresponding to anatomical locations). Support surfaces can either be **powered** or **non-powered**. Power is used in some devices to alter the immersion and envelopment characteristics of the surface, to control the microclimate or, periodically, to redistribute pressure. Powered features designed to influence the microclimate include heating, cooling and controlling moisture. Powered features designed to change reactive load bearing characteristics include **air fluidization** of granular materials and active control of fluid pressure within bladders. An example of the latter case is a support surface that adjusts air volume in response to the weight and/or morphology of the individual. A powered feature designed to affect microclimate is **low-air-loss**. Low-air-loss describes a feature where air is circulated beneath a water vapor permeable cover to control the humidity at the interface between the individual and the support surface (microclimate control).

Support surface characteristics such as immersion, envelopment, and heat and moisture permeability will vary substantially from device to device both within and across categories (active or reactive), if they are powered or non-powered, or if they implement such features as alternating pressure and low-air-loss. The Rehabilitation Engineering and Assistive Technology Association of North America (RESNA) in collaboration with the National Pressure Ulcer Advisory Panel (NPUAP) has published standard test methods for quantifying these characteristics.³ The test results are intended to assist clinicians and consumers in selecting support surfaces that best meet the needs of individual users. The Tissue Viability Society also published similar consensus-based test standards for active surfaces in 2010.⁴

Pressure ulcer risk factors vary from person to person. Support surfaces should be chosen on an individual basis depending on these personal needs. In all cases, the manufacturer’s recommendations for the use and maintenance should be followed. Standards also serve manufacturers as a product development guide and to enhance quality assurance.

Microclimate refers to the temperature and humidity of the interface between the support surface and the individual. Pressure distribution, shear management and microclimate influence a person’s risk of developing a pressure ulcer.⁵ The role of microclimate in pressure ulcer development is discussed in the *Etiology of Pressure Ulcers* section of this guideline.

Reactive support surfaces are designed to reduce the risk of pressure ulcer development by deforming in response to applied load (i.e., the individual’s weight and/or morphology). The goal is to provide deep immersion and a high degree of envelopment to reduce sustained deformation caused by pressure concentrations over bony prominences.

Active support surfaces are design to reduce the risk of pressure ulcer development by periodically shifting

the areas of support from between anatomical locations so that deformation is not sustained over any one area. The weight-shifting feature is typically achieved by cycling air into and out of bladders within the support surface. This feature is called alternating pressure.

Lateral rotation, percussion and vibration are examples of therapeutic functions of support surfaces that are not intended to reduce pressure ulcer risk.

Refer to the *Glossary* for selected terms and definitions associated with support surfaces. Refer to the NPUAP website (www.npuap.org) for a complete list of terms and definitions developed by the NPUAP Support Surface Initiative (S3I).⁶

Support Surface Use

Support surfaces are an important element in pressure ulcer treatment because they provide an environment that enhances perfusion of injured tissue. Support surfaces alone neither prevent nor heal pressure ulcers. They are to be used as part of a total management plan for pressure ulcer prevention and treatment.

This section addresses support surface recommendations for individuals at high risk of pressure ulcers or with existing pressure ulcers. Information about support surface use following surgical repair of pressure ulcers can be found in under *Surgery for Pressure Ulcers*. Where applicable (i.e., recommendations specifically relevant to the specific population), additional recommendations on support surface use are also located in the *Special Population* sections of this guideline.

General Recommendations for Mattress and Bed Support Surfaces

1. **Select a support surface that meets the individual's needs. Consider the individual's need for pressure redistribution based on following factors:**
 - level of immobility and inactivity;
 - need for microclimate control and shear reduction;
 - size and weight of the individual;
 - risk for development of new pressure ulcers; and
 - number, severity, and location of existing pressure ulcer(s). (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Immobility is the key condition that increases risk of pressure ulcers. This risk is increased when immobile individuals are too weak to turn or reposition themselves, are experiencing pain and discomfort on movement, or when they are unaware of the need to move about in bed. Individuals who must have the head of the bed elevated for medical purposes may benefit from shear reduction surfaces. Individuals with damp skin (e.g., commonly from perspiration, fever and incontinence) may benefit from microclimate control. Further information on microclimate is in the *Emerging Therapies for Prevention of Pressure Ulcers* section of the guideline.

Selection of support surfaces should consider the individual's body dimensions, ensuring there is adequate space for repositioning. Further information on selection of support surfaces is in the sections of the guideline for *Special Populations*, as appropriate.

Individuals should not lie on a pressure ulcer; however, there are instances where the individual cannot be positioned off the ulcer and instances because the individual has ulcers on multiple anatomical sites. To improve perfusion to injured skin and existing pressure ulcers, support surfaces with additional features (e.g., alternating pressure, low-air-loss or air fluidized) may be needed for individuals with existing full thickness ulcers (i.e., Category/Stage III, IV and unstageable pressure ulcers), while other support surfaces may suffice for partial thickness pressure ulcers (i.e., Category/Stage I and II pressure ulcers). However, selection of a support surface should be individualized based on the factors detailed in the above recommendation statement. See below for recommendations on selecting support surfaces specifically for individuals with existing pressure ulcers.

- 2. Choose a support surface that is compatible with the care setting. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. When selecting a support surface, consideration should be given to where the support surface and/or bed will be placed. Consider the weight of the bed, the structure of the building, the width of doors, the availability of uninterrupted electrical power, and safe location for the pump/motor, including its ventilation. Plans should be in place for the contingency of power failure.

Caregivers should follow supplier's instructions regarding maintenance schedules and care and use of the support surface. To prevent falls, electrical cords should be kept away from transfer/walk areas. Support surface pumps/motors should not be obstructed by pillows, bedding, blankets, or clothing. The obstructed motor may overheat and fail to operate. These considerations are especially important for individuals in the home care setting and should be reviewed with the individual or caregiver.

- 3. Examine the appropriateness and functionality of the support surface on every encounter with the individual. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. It is difficult to determine whether the chosen support surface will work for a given person until that individual is actually on the support surface. Any support surface can fail or be less than adequate for an individual's needs. Caregivers must monitor for power failure and 'bottoming out' and implement the contingency plan if needed.

- 4. Identify and prevent potential complications of support surface use. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Proper selection and operation of support surfaces is the key to preventing complications. Correctly fitting the mattress to the bed base will mitigate entrapment risks. Overlays placed on top of existing mattresses can elevate the surface to the level of side rails. The top of the side rail should be more than 220 mm (8.66 inches) above the uncompressed mattress (International Electrotechnical Commission [IEC] 60601-2-52). The additional height may make it difficult to transfer onto the bed from a seated position. High beds may be difficult to get out of, increasing the risk of falling and injury.

Beds that produce air flow at the skin interface can accelerate the evaporation of perspiration and can in some cases lead to dehydration.⁷ This insensible loss should be considered in daily fluid intake. Beds that lead to a sensation of floating may lead to disorientation and confusion; in such cases, reorientation and explanations of the bed's function may be helpful. Powered support surfaces can be noisy, may generate heat, and can have motion. One trial conducted in older women confined to bed (n = 10) reported that automated tilted beds were associated with a non-significant change in high frequency components of the heart rate; however, this is an infrequent occurrence⁸ (indirect evidence). These factors may be well-tolerated or may not be acceptable.


- 5. Verify that the support surface is being used within its functional life span, as indicated by the manufacturer's recommended test method (or other industry recognized test method) before use of the support surface. (Strength of Evidence = C; Strength of Recommendation = 👍)**

It is widely recognized that support surfaces have a finite life span. Determining the condition of a support surface can be accomplished through contractual support surface performance verification conducted by the manufacturer, or by hospital staff trained in the use of industry recognized test methods.^{9,10}

- 6. Continue to reposition individuals placed on a pressure redistribution support surface. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Repositioning is still required for pressure relief and comfort when a support surface is in use. However, the frequency of repositioning may alter as a result of using

a support surface. The *Repositioning and Early Mobilization* section of the guideline provides recommendations and discussion on repositioning. The sections of the guideline for *Special Populations* also provide recommendations for repositioning associated with different support surfaces and medical conditions.

7. **Choose positioning devices and incontinence pads, clothing and bed linen that are compatible with the support surface. Limit the amount of linen and pads placed on the bed. (Strength of Evidence = C; Strength of Recommendation = )**


This statement is based on expert opinion. Devices with sharp edges should not be used near support surfaces. Foam positioning wedges can be used to raise the head of the bed in some air fluidized beds.

Bed linen, foam devices, and disposable incontinence pads may be necessary to manage comfort, positioning, and moisture or drainage. Consider the individual's condition and the types of support surfaces being utilized in order to determine the type and amount of linen to be used. A general rule of thumb is "less is best." In one laboratory study, the impact of adding various combinations of incontinence pads and linen layers to a low-air-loss and to a therapeutic foam support surface was investigated using a pelvic indenter model. The findings indicated statistically significant ($p < 0.0001$) increases in peak sacral interface pressure for all combinations of additional bed linen and/or incontinence pads compared with a single fitted sheet. The percentage increase in peak sacral interface pressure was larger for low-air-loss beds compared with a high specification foam mattress¹¹ (indirect evidence).

When selecting linens and incontinence pads to place on support surfaces with air fluidized or low-air-loss features, avoid impeding airflow as this will interfere with the thermal performance properties of the surface. If plastic-backed incontinence pads must be used, use them for dignity when the individual is ambulating and remove them when at bedrest, or allow the pad to remain open or placed loosely against the skin to promote as much air flow as possible.¹²

Mattress and Bed Support Surfaces for Pressure Ulcer Prevention

Pressure redistributing support surfaces are designed to either increase the body surface area that comes in contact with the support surface (to reduce interface pressure) or to sequentially alter the parts of the body that bear load, thus reducing the duration of loading at any given anatomical site. Measures of interface pressure (pressure at the interface between the body and the supporting surface) have been frequently reported as surrogate indicators of support surface efficacy. However, the relevance of interface pressure measurement is questionable given wide inter-individual responses to applied loads (see *Etiology of Pressure Ulcers* section of the guideline).

1. **Use a high specification reactive foam mattress rather than a non high specification reactive foam mattress for all individuals assessed as being at risk for pressure ulcer development. (Strength of Evidence = A; Strength of Recommendation = )**

Studies that have compared standard and alternative foam mattresses generally fail to provide an adequate description of the "standard hospital mattress" used as a comparator.

A systematic review^{13, 14} pooled the results of five randomized controlled trials (RCTs) comparing foam alternatives with the standard hospital foam mattress. The meta-analysis concluded that high specification foam mattresses are associated with a significant reduction in pressure ulcer incidence in at risk individuals when compared to standard hospital foam mattresses. Studies that have compared standard and alternative foam mattresses varied in quality, and all failed to adequately define a "standard hospital mattress", limiting comparison between the separate studies. Some of the individual studies only reported Category/Stage II or greater pressure ulcer incidence and some included Category/Stage I pressure ulcers in the reported incidence rate. McInnes et al. (2011)¹⁴ concluded that high specification foam mattresses reduced the incidence of pressure ulcers in individuals at risk (risk ratio [RR] = 0.40) (Level I study).

Russell et al. (2003)¹⁵ conducted one of the RCTs reported in the McInnes et al. review.^{13, 14} This study involved 1,168 participants from elderly acute care, orthopedic, and rehabilitation wards. The experimental group (n = 562) received a viscoelastic polymer foam mattress, and the control group (n = 604) received a standard hospital foam mattress. The primary outcome in this study was non-blanchable erythema (Category/Stage I pressure ulcer). A non-significant decrease in the incidence of Category/Stage I pressure ulcers occurred in participants allocated to the experimental group (10.9% to 8.5%, p = 0.17). However, survival analysis (at seven days) showed a statistically significant decrease in Category/Stage I pressure ulcers in the experimental group (p = 0.042) (Level 1 study).

Berthe et al. (2007)¹⁶ performed a RCT that included participants in medical and surgical units (n = 1,729). The experimental group had foam mattresses with block structure, and the control group was on standard hospital mattresses. No significant difference in pressure ulcer incidence was found between the experimental and control group (p = 0.154). However, the time to develop a pressure ulcer was longer in the group with the alternative foam mattress (31 days) than in the control group (18 days) (p < 0.001) (Level 1 study).

In a small RCT, Gray et al. (2000)¹⁷ compared a new foam mattress (n = 50) to a standard hospital foam mattress (n = 50). One hundred participants from surgical, orthopedic, and medical wards were recruited. There was no significant difference between the two groups in Category/Stage II to IV pressure ulcer incidence (2% in both populations). This study has a number of methodological flaws (Level 2 study).

There is no evidence of the superiority of one higher specification foam mattress over any other higher specification foam mattresses. In their systematic review, McInnes et al. (2011)¹⁴ pooled five RCTs that compared different higher specification foam mattresses. They found no apparent differences in the incidence of pressure ulcers that develop among individuals resting upon the mattresses.


1.1. Review the characteristics of foam mattresses used in the facility for pressure ulcer prevention to ensure they are high specification. (Strength of Evidence = C; Strength of Recommendation = )

Table 1 outlines consensus opinion on the minimum characteristics for a product to be considered a high specification foam mattress.

Table 1: Consensus on characteristics that constitute a high specification foam mattress^{2, 18}

Characteristic	Explanation	High specification mattress
Classification	Classification according to the Australian Standards (AS2281-1993). ¹⁹	Type H/HR ^{19, 20} H - conventional resilience, heavy duty HR - high resilience
Density – hardness in single layer mattresses	Density is the weight of the foam in kilograms per cubic meter kg/m ³ (pounds per cubic foot [PCF]). Hardness is the ability of foam to ‘push back’ and carry weight, and is defined as the amount of force (in Newtons) required to indent a sample of the foam by a specific percentage of the original thickness. This is known as the indentation force deflection (IFD). ²¹ In Australia and Europe hardness is measured at 40% IFD and in US hardness is measured at 25% IFD. ²⁰ Density/hardness defines the grade of foam and is stated with density followed by hardness.	35 kg/m ³ (2.18 PCF) 130 Newtons minimum for single layer foam mattresses 35 —130 (density-hardness minimum grade for single layer foam mattress)
Support factor	Support factor is a component of comfort that is calculated as a ratio:	IFD: 1.75 to 2.4. ¹⁹

Characteristic	Explanation	High specification mattress
	<p>IFD at 65%</p> <p>IFD at 25% = support factor.²¹</p> <p>A higher value usually indicates a softer feel and good base support.²¹</p>	
Depth	Consider depth of the mattress alongside density/hardness. Different foam grades require different depth to manage upper body weight and prevent 'bottoming out'.	150 mm (5.9 inches). ²² Mattress depth needs increasing to support bariatric load. ²³
Mattress cover	<p>Vapour permeability: the relevant measurement is moisture vapour transmission rate (MVTR). Increasing the MVTR potentially allows the trans-epidermal water loss (TEWL) of intact skin to transpire through the cover.²⁴ Decreasing the MVTR of the cover protects the foam from moisture degradation. Changing the MVTR becomes a compromise between managing local climatic conditions and the individual's TEWL.</p> <p>Allows for partial immersion in foam</p> <p>Wrinkling: may add additional pressure at skin surface</p> <p>Shear resistance: can be reduced with a low friction fabric.²⁵</p> <p>Infection control:</p> <ul style="list-style-type: none"> • water proofing – prevents contamination of foam • welded seams prevent ingress of fluids • waterfall flap cover over zips • cleaning according to facility protocol and manufacturers guidelines <p><i>Fire retardant properties:</i> material must meet local standards</p>	<p>MVTR: minimum 300 g/m²/24hrs.²⁶ (equivalent to normal TEWL)</p> <p>Often 2 way stretch</p>
Other considerations	<p>Multi-layering of various grades / types of foam alters the design features</p> <p>Low resilience/slow recovery/memory foam/ viscoelastic: increases the surface area contact, redistributes pressure, reduces peak pressures and allows immersion of bony prominences. Has potential to increase skin surface temperature.²⁷</p> <p>Castellated/cross-cut foam: partial thickness cuts made in a regular block pattern on the top of the foam increases surface contact area, potentially reducing friction and shear.²⁸</p> <p>Side walls: a border or stiffener along the edge increases firmness and assists mobility and transfers</p> <p>Safety sides (concave shape): may reduce risk of falls but may also reduce bed mobility, need to consider facility restraint policy</p> <p>Hinging system: wedges removed on inner border to allow for folding/bending of mattress to accommodate back rest, upper and lower leg sections to conform to profiling beds.</p>	<p>Hardness may increase from 130 Newtons for the base layer. Hardness may decrease in upper layers and may be less than the minimum standard for a single layer mattress</p>

1.2. Consider using other reactive support surfaces for individuals assessed as being at risk for pressure ulcer development. (Strength of evidence = C; Strength of Recommendation = 🖱)

Johnson et al^{29, 30} conducted a prospective study (n = 297) investigating the prevalence of facility-acquired pressure ulcers in a community hospital. The study compared pressure ulcer prevalence rates in general surgical and medical telemetry units in which participants were cared for on low-

air-loss beds to cardiac, renal and medical pulmonary units that had standard hospital mattresses (specifications were not defined). Although no significant differences in prevalence rates of facility-acquired pressure ulcers were noted, the study did not address confounding issues, including significantly higher Braden Scale scores in the population cared for on low-air-loss beds (Level 3 study).

A small, Dutch study.³¹ included in the McInnes et al. review.^{13, 14} compared polyether foam to static air overlay mattress in a sample of nursing home residents (n = 83). The study concluded that fewer participants on the air mattress overlay developed Category/Stage II or greater pressure ulcers but difference was not significant (p = 0.088) (Level 2 study).

Black et al. (2012)³² compared a low-air-loss bed with microclimate control to an integrated powered air redistribution bed without low-air-loss for prevention of pressure ulcers in an intensive care unit (ICU) cohort (n = 52). Findings from this study indicated that the low-air-loss surface was more effective than intermittent pressure mattresses in preventing and treating pressure ulcers (0% versus 18%, p = 0.046) over a short time frame (mean follow up period was 5.7 days) (Level 3 study).

2. Use an active support surface (overlay or mattress) for individuals at higher risk of pressure ulcer development when frequent manual repositioning is not possible. (Strength of Evidence = B; Strength of Recommendation = 👍)

In the McInnes et al. systematic review,^{13, 14} data from two studies comparing active support surfaces and standard mattresses were pooled. The results suggested that fewer pressure ulcers develop on active support surfaces as compared to standard hospital mattresses. However, the poor quality of these trials must be acknowledged, and the evidence is dated (many of the support surfaces are no longer available).

In one RCT³³ reported in the McInnes et al. review,¹⁴ Vanderwee et al. (2005)³³ compared alternating pressure air mattresses with no turning protocol to high specification foam mattresses with four-hourly repositioning in 447 participants from surgical, internal medicine, and geriatric wards. This study showed no significant difference between the incidence of Category/Stage II or greater pressure ulcers among individuals cared for either on an active support surface (15.6%) or on a high specification foam mattress (15.3%). There were more heel ulcers in the control group and more severe ulcers in the treatment group. However, the high incidence of pressure ulcer development and presence of full thickness ulcers in both groups must be acknowledged (Level 1 study).


In a small RCT also included in the McInnes et al. review,¹⁴ Sanada et al. (2003)³⁴ assigned 82 participants (individuals who had experienced a stroke, recovering from surgery or with a terminally illness) to either of two types of active support surfaces (n = 29 and n = 26) or a standard hospital mattress (n = 27). Incidence of Category/Stage I to IV pressure ulcers on the active support surfaces was 19.2% and 3.4%, respectively, and 37% on the standard hospital mattress (p < 0.01). However, the methodological flaws in this study should be recognized (Level 2 study).

In another RCT, Vermette et al. (2012)³⁵ compared an air-inflated overlay with a micro-fluid overlay for preventing pressure ulcers in participants (n = 110) in a range of acute and long term care facilities who were assessed as being at moderate to high risk. There were no statistically significant differences between the two active support surface overlays when compared on pressure ulcer incidence (4% for the air inflated overlay versus 11% for the micro-fluid overlay, p = 0.2706) or participant rated comfort (p = 0.7129). The micro-fluid overlay was reported to be more expensive (p ≤ 0.001) (Level 1 study).

The evidence suggests that active support overlays and mattresses have a similar efficacy in terms of reducing pressure ulcer incidence. Nixon et al. (2006)³⁶ undertook a multicenter RCT to assess the effectiveness of alternating pressure mattress replacements and alternating pressure mattress overlays. Acute and elective individuals admitted to vascular, orthopedic, medical, and geriatric wards were included in the trial (n = 1,971). The incidence of Category/Stage II or greater pressure ulcers for those on an alternating overlay was 10.7% (106 out of 989) and 10.3% (101 out of 982) for those on an

alternating replacement mattress ($p = 0.75$). No significant difference in pressure ulcer incidence was seen between the alternating overlay and mattress replacement; however more individuals on the overlay requested to be changed to another device, and the alternating pressure mattress was more cost effective than an alternating pressure overlay (data not presented) (Level 1 study).


The currently limited evidence suggests that alternating pressure active support surfaces with different deflation/inflation cycles also have a similar efficacy. In a RCT conducted in 25 hospital wards in Belgium, Demarré et al. (2012)³⁷ compared alternating low pressure air mattresses with different deflation/inflation cycles. The experimental group ($n = 298$) were cared for on alternating low pressure air mattresses with a multi-stage deflation/inflation cycle of between 10 and 12 minutes. The control group ($n = 312$) had alternating low air pressure mattresses with a standard 10 minute deflation/inflation cycle. There was no significant difference in the cumulative incidence of Category/Stage II to IV pressure ulcers between the experimental group and the control group (5.7% versus 5.8%, $p = 0.97$). The median time to develop a pressure ulcer also was not significantly different between the experimental group and the control group (five days versus eight days, $p = 0.182$). There appears to be no benefit of alternating low pressure with multi-stage inflation/deflation cycles over a standard cycle alternating low pressure air mattress in preventing pressure ulcers (Level I study).

2.1. Do not use small cell alternating pressure air mattresses or overlays. (Strength of Evidence = B; Strength of Recommendation = )

The recommendation to avoid using small cell alternating pressure mattresses and overlays has been retracted. In one older study³⁸ pressure ulcers occurred more frequently in individuals who received a small cell mattress (diameter 1.5 to 2 inches or 3.8 to 5.1 cm) compared with a large cell mattress (diameter 6 inches or 15.25 cm). However, both the mattresses trialled in this study used technology and materials that are outdated and the results cannot be extrapolated to contemporary technologies. In another study,³⁹ the two trial mattresses with different cell sizes also differed with respect to other components of product design and function. When selecting an alternating pressure mattress or overlay the choice should be individualized according to pressure ulcer risk, comfort of the individual and effectiveness determined through regular skin assessments. Further information is available at <http://internationalguideline.com/statements>.

Mattress and Bed Support Surfaces for Individuals with Existing Pressure Ulcers

Individuals with an existing pressure ulcer are at higher risk for developing additional pressure ulcers.

1. Wherever possible, do not position an individual on an existing pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = )

This statement is based on expert opinion. When ulcers are present on two or more turning surfaces (e.g., the sacrum and trochanters) the individual will need to be repositioned on the ulcers, because she or he cannot continuously lie on the same turning surface.^{36, 40}

2. Consider replacing the mattress with a support surface that provides more effective pressure redistribution, shear reduction, and microclimate control for the individual if he or she:
- cannot be positioned off the existing pressure ulcer;
 - has pressure ulcers on two or more turning surfaces (e.g. the sacrum and trochanter) that limit turning options;
 - fails to heal or demonstrates ulcer deterioration despite appropriate comprehensive care;
 - is at high risk for additional pressure ulcers; and/or
 - 'bottoms out' on the existing support surface. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based on expert opinion. Unless the individual's clinical condition has changed (e.g., the individual is now mobile, awake, and has adequate perfusion), the support surface on which the pressure ulcer developed usually does not provide an appropriate environment for healing. A different support surface is often required to provide better pressure redistribution and control microclimate, thus reducing further ischemia in pressure ulcers.

When pressure ulcers deteriorate or fail to heal, the clinician should consider replacing the existing support surface with one that will provide a properly matched support surface environment in terms of pressure, shear, and microclimate for the individual. Changing the support surface is only one of several strategies to consider. More frequent repositioning of the individual may be needed (see the *Repositioning and Early Mobilization* section of the guideline). The individual and his or her pressure ulcer should be re-evaluated (see the *Assessment of Pressure Ulcers and Monitoring of Healing* section of the guideline). Preventive interventions and local wound care should also be intensified as needed.

When the individual has pressure ulcers on two or more sites on the trunk of the body, options for repositioning are diminished. The individual will spend relatively more time on unaffected areas of the body therefore prevention becomes even more crucial in individuals at risk of forming additional ulcers. 'Bottoming out' on a support surface (i.e., when the support surface does not properly support the individual) is a clear indication that pressure redistribution is inadequate and the surface must be changed.

Cassino et al. (2013)⁴¹ compared two different reactive support overlays for managing individuals with an existing Category/Stage I to IV pressure ulcer. Participants were assigned to a gel overlay (n = 37) or an overlay described as a three dimensional (3D) macro-porous, multilayer, polyester overlay (n = 35) for 12 weeks. Approximately 30% of participants in both groups were suspended from the study due to deteriorating pressure ulcer condition (p = not significant [ns] between groups). There was no significant difference in the number of pressure ulcers that resolved (8.57% for gel versus 13.5% for 3D, p = ns). Although the 3D overlay was reported to be associated with greater reduction in pressure ulcer surface area, the results were not convincing as there were numerous methodological flaws. The researchers cautioned that as neither overlay offloaded pressure, the potential for healing was limited (Level 2 study).

3. Before replacing the existing mattress:
- evaluate the effectiveness of previous and current prevention and treatment plans; and
 - set treatment goals consistent with the individual's goals, values, and lifestyle. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Support surfaces may be cumbersome to get in and out of, noisy if powered, or frightening if the surface is moving. Ascertain the individual's comfort, concerns and preferences when considering a support surface change.


4. Consider using a high specification reactive foam mattress or nonpowered pressure redistribution support surface for individuals with Category/Stage I and II pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)

Individuals with an existing pressure ulcer are at higher risk for developing additional pressure ulcers. In many cases, a small Category/Stage I or II pressure ulcer can be easily offloaded with repositioning, such as turning side to side (for sacral ulcers) or using heel elevation. However, clinical judgment may lead the health professional to change surfaces in high risk or hemodynamically unstable individuals with Category/Stage I or II pressure ulcers, particularly if there are multiple ulcers at multiple sites or the individual cannot be moved off the pressure ulcer.

There is no evidence that powered support surfaces with air fluidized, low air loss and/or alternating pressure features are more effective than other high specification support surfaces for the treatment of existing Category/Stage I and II pressure ulcers.

Other powered support surfaces have been used clinically for Category/Stage I and II pressure ulcers. Some evidence found that pressure ulcers heal on powered support surfaces;^{42, 43} however, methodological limitations of these studies reduced the ability to recommend these support surfaces for individuals with Category/Stage I and II pressure ulcers (Level 5 studies). Although powered support surfaces may support healing, nonpowered surfaces may be sufficient.

Nixon et al. (2006)³⁶ reported on 113 participants with Category/Stage II ulcers randomized to receive either an alternating pressure overlay or an alternating pressure mattress replacement. There was no significant difference between groups for median time to healing (20 days for each group, $p = 0.86$). Complete healing between the two groups was also comparable (35% healed in the mattress group and 34% healed in the overlay group). The findings suggest that for alternating pressure support surfaces neither a mattress nor an overlay is superior when compared on clinical outcomes alone (Level 1 study).

5. Select a support surface that provides enhanced pressure redistribution, shear reduction, and microclimate control for individuals with Category/Stage III, IV, and unstageable pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = )

Randomized controlled trials compare healing rates for Category/Stage III and IV pressure ulcers on a range of different support surfaces.^{15, 44-57} It is difficult to make definitive recommendations based on these studies due to differences in the support surfaces tested, variations in outcome measures (i.e., complete healing, time to healing, reduction in wound size, or assessment of wound improvement/deterioration), small sample sizes, and other methodological inconsistencies. There is insufficient evidence on which to base definitive recommendations for using one surface over another.

The results of properly designed and conducted RCTs that examined the effects of support surfaces on the healing of Category/Stage III and IV pressure ulcers are summarized below. Most of these studies were published between 1987 and 2005. Since that time, support surface technology has improved for powered surfaces as well as nonpowered surfaces that served as comparisons in these early studies. Despite these limitations, the studies cited below continue to constitute the best available evidence. This guideline update did not identify new RCTs of healing of Category/Stage III and IV pressure ulcers on nonpowered surfaces published between January 2008 and July 2013. The results of recent lower quality studies did not add new insights due to limitations such as low methodological quality of the design of the study, lack of blinding and lack of standardized treatment.^{43, 58} Furthermore, no distinction was made between the treatment of Category/Stage I and II pressure ulcers and Category/Stage III, IV and unstageable pressure ulcers.

Beds with air fluidized features produced better healing outcomes for Category/Stage III and IV pressure ulcers than standard beds⁵⁷ (Level 2 study), alternating air with foam pad⁴⁴ (Level 1 study), and a variety of non-air fluidized support surfaces^{47, 51} (Level 1 studies). In addition to these RCTs published in the 1980s and early 1990s, Ochs et al. (2005)⁵⁹ conducted a retrospective chart review study and reported better weekly healing rates associated with beds with air fluidized features. This study had multiple design flaws, and the results should be reviewed with caution (Level 3 study).

Beds with low-air-loss features resulted in better healing outcomes for Category/Stage III and IV pressure ulcers than foam mattresses in a 1993 study. Results indicated that there was a 2.5 fold improvement in healing rates on the low-air-loss beds⁴⁶ (Level 1 study).

Mattresses and overlays with alternating pressure features are recommended and used by clinicians for treatment of pressure ulcers; however, no published studies demonstrating better healing outcomes for Category/Stage III or IV pressure ulcers in comparison to other types of support surfaces were identified.

Other powered and nonpowered support surfaces have been used clinically for Category/Stage III, IV, and unstageable pressure ulcers. Pressure ulcers have healed on powered and nonpowered support surfaces (Level 1 study),⁴⁶ (Level 3 study),⁶⁰ and (Level 5 studies).^{43, 58} However, no publications that met inclusion criteria for this guideline revision provided evidence for a statistically significant effect of these surfaces on healing of Category/Stage III, IV, and unstageable pressure ulcers.

- 6. Select a support surface that provides enhanced pressure redistribution, shear reduction, and microclimate control for individuals with suspected deep tissue injury if pressure over the area cannot be relieved by repositioning. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Support surface use in suspected deep tissue injury with intact skin has not been rigorously examined in clinical trials. The true level and degree of tissue damage cannot be determined until the deep tissue injury fully evolves. At early stages of evolution (when the skin is still intact), offloading and pressure redistribution may allow reperfusion of ischemic and injured tissue, limiting the extent of infarcted or dead tissue. Infarcted tissue is not salvageable. For all practical purposes, evolving deep tissue injury should be provided the same level of pressure redistribution as a Category/Stage III or IV pressure ulcer. Once the ulcer has fully evolved, support surface needs can be re-evaluated.

General Recommendations on Seating Support Surfaces

When a person is seated, her or his body weight is supported by a relatively small surface area (i.e., buttocks, thighs, and feet), leading to high interface pressures combined with limited opportunities to redistribute body weight to other anatomical sites. Prolonged sitting results in a strong predisposition to pressure ulcer development, particularly in the ischial area.

- 1. Individualize the selection and periodic re-evaluation of a seating support surface and associated equipment for posture and pressure redistribution with consideration to:**
 - **body size and configuration;**
 - **the effects of posture and deformity on pressure distribution; and**
 - **mobility and lifestyle needs. (Strength of Evidence = C; Strength of Recommendation = 👍)**
- 2. Select a stretchable/breathable cushion cover that fits loosely on the top surface of the cushion and is capable of conforming to the body contours. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. A tight, nonstretch cover will adversely affect cushion performance. Covers that fit loosely on the top surface and those that are made from a stretch material are better-suited to let the cushion material deform as intended to allow immersion.

- 2.1. Assess the cushion and cover for heat dissipation. Select a cushion and cover that permit air exchange to minimize temperature and moisture at the buttock interface. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Evidence suggests that a rise in tissue temperature increases the susceptibility to pressure ulcers.^{61, 62}

- 3. Inspect and maintain all aspects of a seating support surface to ensure proper functioning and meeting of the individual's needs. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Seating cushions should be inspected for signs of wear on a daily basis. The support surface (chairs and wheelchairs) should be inspected according to the manufacturer's recommendations.

4. **Provide complete and accurate training on use and maintenance of a seating support surface (including wheelchairs) and cushion devices delivered to the individual. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Seating Support Surfaces to Prevent Pressure Ulcers

1. **Use a pressure redistributing seat cushion for individuals sitting in a chair whose mobility is reduced. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

Ensure that selection of a pressure redistributing seat cushion is appropriate to the individual. The *Special Populations: Bariatric Individuals* section of the guideline provides recommendations on selection of equipment for bariatric individuals. The guideline section *Special Populations: Individuals with Spinal Cord Injury* provides recommendations and discussion on seating surfaces for individuals with SCI.

Geyer et al. (2001)⁶³ conducted a RCT as a pilot study involving 32 elderly residents of two skilled nursing facilities. Among the inclusion criteria was the individual's ability to tolerate sitting in a wheelchair for at least six hours each day. The experimental group (n = 15) received a pressure redistributing cushion, and the control group (n = 17) received a foam cushion. In total, 16 out of 32 participants developed pressure ulcers, and there were no significant differences between the groups. When looking only at ischial pressure ulcers, the incidence was significantly lower in the experimental group ($p < 0.005$) (Level 2 study).

Brienza et al. (2010)⁶⁴ conducted a randomized trial in nursing home clients (n = 180) comparing pressure ulcer incidence over a six month period. The study group were provided with a fitted wheelchair and randomized into skin protection (n = 113) seated on an air, viscous fluid and foam cushion; or a gel and foam cushion. The control group received a 7.6 cm crosscut segmented foam cushion (n = 119). The control group experienced a significantly greater incidence of ischial tuberosity pressure ulcers (6.7% versus 0.9%, $p = 0.04$). When the ischial tuberosity pressure ulcers were combined with sacral pressure ulcers, the incidence was not significantly different between groups (17.6% control group versus 10.6% experimental group, $p = 0.14$). Kaplan Meier methods did not demonstrate significant differences in the cumulative incidence of pressure ulcers between the groups. There was no control for conditions outside of chair time, frequency of repositioning was not reported and staff were aware of participation in the study (Level 2 study).

Collins (1999)⁶⁵ performed a non-randomized controlled trial involving elderly individuals in acute care (n = 40). The experimental group had armchairs with pressure redistribution cushions, padded armrests, and side wings to support the head, and the control group had standard armchairs with foam on the seat. The experimental group developed significantly fewer pressure ulcers ($p < 0.0001$) (Level 3 study).

Defloor et al. (2000)⁶⁶ investigated different types of cushion including air, water, hollow fiber, foam, combination gel and foam, and sheepskin (n = 28 cushions) in a laboratory study involving healthy volunteers. Interface pressure was measured after one hour of immobilization. When cushions were combined according to type, the air cushion category had the lowest interface pressure ($t = -6.40$, 95% CI -9.17 to -4.65 , $p < 0.01$ versus armchair); however, water cushions and foam cushions did not differ significantly to air cushions. Within the foam cushion category (n = 9 cushions) there was a significant difference between the various cushion types, with the two visco-elastic foam cushions having maximum interface pressures approximately 38% higher than the armchair ($p < 0.01$). Cushions with the lowest maximum interface pressure were described by the manufacturers as polyethylene-urethane (7 cm, 85 kg/m³), polymer (no specifications), vinyl (no specifications) and shock absorbing polyester foam (60 kg/m³). Many of the gel cushions, combination cushions and the synthetic sheepskin had negligible impacts on interface pressures (all $p = ns$ versus armchair) (indirect evidence).

Seating Support Surfaces for Individuals with Existing Pressure Ulcers

1. **Refer individuals to a specialist seating professional for evaluation if sitting is unavoidable. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
2. **Select a cushion that effectively redistributes the pressure away from the pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍)**

These statements are based on expert opinion. Cushion construction achieves pressure redistribution in one of two basic methods: immersion/envelopment or redirection/off-loading. Envelopment is the capability of a support surface to deform around and encompass the contour of the body. Cushions that utilize envelopment must deflect and deform to immerse the buttocks in the material. Flat cushions must deflect more than contoured cushions. The anthropometrics of the pelvis require about 50mm (2 inches) of immersion for effective envelopment due to the inferior position of the ischial tuberosities (assuming there is no asymmetry in the pelvis). Cushions that redirect loads accomplish this via relief areas in the cushion surface. Some require customization. Off-loading cushions generally require that the individual sit on the cushion in a specific, consistent manner. Therefore, the assessment must include a determination on the individual's ability to consistently reproduce this position, and confirmation that no significant functional tradeoffs occur.

3. **Use alternating pressure seating devices judiciously for individuals with existing pressure ulcers. Weigh the benefits of off-loading against the potential for instability and shear based on the construction and operation of the cushion. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Alternating pressure seating devices have been used in many clinical settings.⁴⁵ A study by Burns et al. (1999)⁶⁷ concluded that there is a similar relief in pressure over the ischial tuberosities between a dynamic cushion during the low pressure phase compared with a tilt-in-space wheelchair with a conventional cushion. Individual responses to the high pressure phase may vary. Because the potential for shear across alternating cells exists, the effect on the individual should be carefully observed.

Wheelchairs equipped with an individually adjusted automated seat providing cyclic pressure relief using a protocol of ten minutes normal sitting and ten minutes offloaded sitting may enhance pressure ulcer closure and decrease wound area. A RCT (n = 44) conducted by Makhsous et al. (2009)⁶⁸ found significantly more improvement in pressure ulcer area closure and Pressure Ulcer Scale for Healing (PUSH) score in individuals using an automated, cyclic relief seat compared with individuals in a standard wheelchair who performed arm push-ups for pressure relief every 20 or 30 minutes. The group using the cyclic pressure relief seating system achieved a mean 45 ± 21% improvement in mean pressure ulcer surface area compared with 10.2 ± 34.8% improvement in the control group (p<0.001). As the study did not address possible differences between groups in preventive measures provided when the individuals were not seated, differences in wound care/dressings, and pressure ulcers size at baseline, it was not possible to recommend an adjusted automated seat above a standard wheelchair with a manual pressure relief regimen (Level 2 study).

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MEDICAL DEVICE RELATED PRESSURE ULCERS

Introduction

Medical device related pressure ulcers are pressure ulcers that result from the use of devices designed and applied for diagnostic or therapeutic purposes. The resultant pressure ulcer generally closely conforms to the pattern or shape of the device.¹ Potential sources of device related pressure ulcers include but are not limited to:

- respiratory devices including:
 - tracheostomy faceplates and securement devices;
 - masks used to deliver non-invasive positive pressure ventilation (NIV) (e.g., biphasic positive airway pressure [Bi-PAP], continuous positive airway pressure [CPAP]);
 - endotracheal (ET) and nasotracheal tubes;
 - oximeter probes, and
 - oxygen tubing/nasal cannulas;
- orthopedic devices including cervical collars, halo devices, helmets, external fixators, immobilizers, plaster casts;
- foley catheters;
- fecal containment devices;
- surgical drains;
- central venous and dialysis catheters;
- intra-aortic balloon pumps;
- intermittent pneumatic compression device sleeves;
- graduated compression stockings; and
- restraints.

Risk for medical device related pressure ulceration may increase as a result of impaired sensation, moisture under the device, poor perfusion, altered tissue tolerance, poor nutritional status and edema.¹

Medical device related pressure ulcers develop due to prolonged and unrelieved pressure on the skin from a medical device. They can also result from poorly positioned or ill-fitting devices or incorrect device use. They may also develop due to poorly fitting or improperly positioned fixation devices used to secure medical equipment.¹ In some instances, the design of the medical equipment can contribute to pressure ulcer development.^{2,3} In certain settings (e.g., adult and pediatric critical care), the heavy burden of technology and equipment utilized in the environment renders the individual particularly vulnerable to the risk for device related pressure ulcers.

Mucosal pressure ulcers are pressure ulcers found on mucous membranes. Mucous membrane is the moist lining of body cavities that communicates with the exterior. These tissues line the tongue, oral mucosa, gastrointestinal (GI) tract, nasal passages, urinary tract, tracheal lining and vaginal tract. Pressure applied to this tissue can render it ischemic and lead to ulceration. Mucosal tissues are especially vulnerable to pressure from medical devices, such as oxygen tubing, endotracheal tubes and tube holders, bite blocks, orogastric and nasogastric tubes, urinary catheters, and fecal containment devices. As outlined in the *Classification of Pressure Ulcers* section of this guideline, the International NPUAP/EPUAP Pressure Ulcer Classification System **should not** be used to categorize mucosal pressure ulcers.

Whenever a pressure ulcer occurs due to a medical device, removal or changing the device should be considered when clinically feasible, and strategies to relieve pressure should be implemented if removing or changing the device is not possible. Assessment and treatment for medical device related pressure ulcers follows the current guidelines for pressure ulcer management.

Risk for Medical Device Related Pressure Ulcers

1. Consider adults with medical devices to be at risk for pressure ulcers. (Strength of Evidence = B; Strength of Recommendation =)

In a secondary analysis of data from eight quarterly point prevalence studies conducted in a US medical center (n = 2,500) Black et al. (2010)⁴ investigated risk factors for facility-acquired pressure ulcers. In a sub-population of adults in medical, surgical and step-down units who did not have a pressure ulcer on admission (n = 2,079), 1.4% of individuals had a medical device related pressure ulcer. For individuals in intensive care who had a facility-acquired pressure ulcer(s) (n = 83 with n = 113 pressure ulcers), 34.5% of the pressure ulcers were deemed to be medical device related. Individuals with a medical device were significantly more likely ($\chi^2 = 6.98$, p = 0.008) to develop a pressure ulcer than those who had no medical device. Presence of a medical device indicated the individual would be 2.4 times more likely (95% confidence interval [CI] 1.2 to 4.8, p = 0.10) to develop a pressure ulcer.

Turjanica et al. (2011)⁵ found a similarly high rate of medical device related pressure ulcers in a convenience sample of individuals receiving oxygen via nasal cannula recruited in a medical/surgical unit (n = 100). In this sample, 37% of individuals experienced skin breakdown, predominantly classified as a Category/Stage I pressure ulcer. In a multivariate analysis, lack of oxygen use prior to hospital admission was the only factor significantly associated with increased likelihood of developing a pressure ulcer of the ear ($\chi^2 = 6.113$, p = 0.013).

1.1. Consider children with medical devices to be at risk for pressure ulcers. (Strength of Evidence = B; Strength of Recommendation =)

Medical device related pressure ulcers are also an important consideration in children. In a retrospective review of children (aged 45 months \pm 8.7 months) who underwent a tracheostomy over a 15 month period in a US pediatric medical center (n = 65), Jaryszak et al. (2011)⁶ reported the rate of tracheostomy related pressure ulcers as 29.2%. Multivariate analysis found that the type (design) of tracheostomy tube (p = 0.003) and lower age groups (under 12 months versus over 12 months) were significant risk factors for a device related pressure ulcer.

In a prospective cohort study conducted in seven neonatal intensive care units (n = 81; mean age 32.5 weeks gestation), Fujii et al. (2010)⁷ reported that 86% of pressure ulcers were associated with CPAP or nasal direction positive airway pressure (DPAP). A multivariate analysis showed an odds ratio (OR) of 4.0 (95% CI 1.04 to 15.42, p = 0.047) for pressure ulcers in children undergoing ET intubation. In this study most of the neonates were extremely underweight, which is also a factor associated with increased pressure ulcer risk.

Schindler et al. (2011)⁸ conducted a multivariate analysis of risk factors for pressure ulcers from retrospective data collected in seven pediatric intensive care units and trauma centers (n = 5,346). A number of factors associated with medical devices were significantly associated with an increased risk of pressure ulcers including mechanical ventilation (OR = 1.334, 95% CI 1.031 to 1.726, p = 0.03); BPAP or CPAP (OR = 2.004, 95% CI 1.509 to 2.661, p < 0.001); high frequency oscillatory ventilation (OR = 2.057, 95% CI 1.208 to 5.134, p = 0.01) and extracorporeal membrane oxygenation (OR = 2.490, 95% CI 1.208 to 5.134, p = 0.01).

In a prospective point prevalence study conducted in children hospitalized for at least 24 hours (n = 412; aged 24 hours to 18 years) Schluer et al. (2012)⁹ reported that 40% of children with an external medical device were assessed as having a pressure ulcer related to the device.

Recommendations for Selecting and Fitting a Medical Device

- 1. Review and select medical devices available in the facility based on the devices' ability to induce the least degree of damage from the forces of pressure and/or shear. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

Facilities, with the input of the health professional, should provide medical devices that will minimize skin damage. This may include selection of softer, more flexible devices. In one large (n = 6,103) quality improvement study conducted in a US trauma center, the number of mucosal pressure ulcer occurrences associated with ET tubes decreased with an institutional change in the brand of ET tube securement device (Level 4 study).¹⁰

Boesch et al. (2012)¹¹ investigated a multifaceted intervention to reduce tracheostomy related pressure ulcers in 834 pediatric individuals. Interventions included the introduction of a hydrophilic foam dressing, in addition to the incorporation of a moisture and pressure free device interface and an extended tracheostomy tube. Significant reductions in tracheostomy related pressure ulcer rates (p = 0.007) and in the number of days with an existing tracheostomy related pressure ulcer (p < 0.0001) were associated with the introduction of the extended tracheostomy tube (Level 4 study).

Skillman et al. (2011)² conducted a quasi-experiment of postoperative Category I pressure ulcer development (and ankle pain) associated with the use of an intermittent compression therapy device used during the perioperative period. The rate of postoperative ankle pain and discomfort decreased for 15% (3/20 individuals) to 5% (1/20 individuals) after changing to a compression device with a flatter surface at the point of contact with the ankle. It was unclear from the report if the original device had been applied and used in accordance with the manufacturer's instructions (indirect evidence).

- 2. Ensure that medical devices are correctly sized and fit appropriately to avoid excessive pressure. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This recommendation is based on expert opinion. Ill-fitting devices can contribute to device malfunction and to an increase in pressure at the device-skin interface resulting in pressure ulceration. Masks used to deliver NIV should be fitted sufficiently tight that air leaks are prevented without creating pressure ulcers. In one moderate quality, retrospective, observational study in 410 children, the presence of an ill-fitting helmet was reported to be a contributory factor to pressure ulcer development in 10.5% of children wearing helmets.¹²

In some cases, medical devices may need to be adjusted or modified in order to prevent pressure ulcers. In one study of complications associated with halo use in children (n= 68), the authors found that cutting or trimming the offending portion of the halo vest reduced discomfort and relieved pressure in most cases (Level 5 study).³

- 3. Apply all medical devices following manufacturer's specifications. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This recommendation is based on expert opinion. Failure to follow the manufacturer's application instruction can result in harm (e.g., skin damage) to the individual and can be a source of liability. Faulty medical devices should be returned to the manufacturer.¹

- 4. Ensure that medical devices are sufficiently secured to prevent dislodgement without creating additional pressure. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This recommendation is based on expert opinion. In situations in which simple repositioning does not relieve pressure, it is important not to create additional pressure by placing excessive dressings beneath tight devices.¹ Consideration for the placement of a prophylactic dressing to protect the skin is further discussed in this section.

Recommendations for Assessment of the Skin and Medical Device

- 1. Inspect the skin under and around medical devices at least twice daily for the signs of pressure related injury on the surrounding tissue. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Frequently inspect the skin beneath adjustable medical devices and continue to lift and/or move the medical device for pressure relief. When prophylactic dressings such as hydrocolloids are used, consider the fragility of the individual's skin and the ease of removal of the dressing when performing routine skin assessments. Detrimental effects such as epidermal stripping may occur with frequent removal of adhesive-based dressings.¹³ Be aware of tubes and medical devices that can become entrapped in skin folds resulting in skin damage, especially in the bariatric population.¹⁴

- 1.1. Conduct more frequent (greater than twice daily) skin assessments at the skin-device interface in individuals vulnerable to fluid shifts and/or exhibiting signs of localized or generalized edema. (Strength of Evidence= C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Changes in fluid volume status, or hypoproteinemic states can result in localized or generalized edema causing a medical device that initially fits properly to exert external pressure to the skin that leads to pressure ulcer formation.¹⁵ The health professional should apply any type of medical device cognizant of the potential for tissue expansion and worsening edema. Depending on the type/purpose of the device, loosening, replacement or removal (i.e., compression stockings) may be advised.

- 2. Classify medical device related pressure ulcers using the International NPUAP/EPUAP Pressure Ulcer Classification System, with the exception of mucosal pressure ulcers. (Strength of Evidence= C; Strength of Recommendation = 👍)**

Pressure ulcers related to medical device use are not a new category of pressure ulcer, and should be classified according to level of tissue loss using the International NPUAP/EPUAP Pressure Ulcer Classification System outlined in the *Classification of Pressure Ulcers* section of this guideline. As outlined in the *Classification of Pressure Ulcers* section of this guideline, the classification system for pressure ulcers of the skin cannot be used to categorize mucosal pressure ulcers.¹⁶

- 3. Educate the individual with a medical device in the community setting and his/her caregivers to perform regular skin inspections. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Individuals in the home setting fitted with a medical device should continue to perform routine skin assessments under or around the device between visits to the health professional.³

Recommendations for Prevention of Medical Device Related Pressure Ulcers

- 1. Remove medical devices that are potential sources of pressure as soon as medically feasible. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This recommendation is based on expert opinion. In order to reduce pressure ulcer risk associated with the use of a medical device, individuals should be routinely reassessed for the continued need for the medical device, and the device should be removed as soon as it is no longer clinically indicated. Extrication cervical collars should be removed and replaced with acute care rigid collars as soon as feasible (see the *Special Populations: Individuals With Spinal Cord Injury* section of the guideline).^{17, 18}

- 2. Keep skin clean and dry under medical devices. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Diaphoresis or excessive secretions underneath a device can cause tissue maceration and contribute to pressure ulcer development.¹ Moisture underneath a medical

device creates an environment in which the skin is more vulnerable to alterations in skin integrity, including irritant dermatitis and ulceration.

- 3. Reposition the individual and/or the medical device to redistribute pressure and decrease shear forces. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion.

- 3.1. Do not position the individual directly on a medical device unless it cannot be avoided. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

- 3.2. Reposition the individual to redistribute pressure and shear forces created by the medical device. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These statements are based on expert opinion. Pressure ulcers may develop under medical devices that have been compressed under the individual causing a localized area of pressure. Where positioning an individual on a medical device cannot be avoided, regularly reposition the individual to redistribute pressure from the device.

Repositioning strategies may vary depending on the individual and the medical device. Simple changes in degree of lateral rotation, head of bed elevation, knee elevation and placement of positioning devices may be used to minimize pressure and shear created by medical devices. For example, ensuring a device is not dependent after repositioning may minimize its gravitational pull on skin and other tissues.

- 3.3. Rotate or reposition medical devices when possible. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Caution: always validate that the depth of an ET tube does not change with tube manipulation.

Wherever possible, a medical device should be regularly repositioned or rotated. Oximetry probes can be repositioned to a different finger, or positioned on the ear lobe every four hours. Endotracheal tubes can be moved laterally to redistribute pressure over different parts of the oral cavity and lips.

- 3.4. Provide support for medical devices as needed to decrease pressure and shear forces. (Strength of Evidence = C; Strength of Recommendation = 👍)**

For example, an ET tube can be supported with the use of a towel under the chin.

- 4. Consider using a prophylactic dressing for preventing medical device related pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = 👍)**

Caution: Avoid excessive layering of prophylactic dressings that may increase pressure at the skin-device interface.

The role of prophylactic dressings in the prevention of device related pressure ulcers is supported by five moderate quality Level 3¹⁹⁻²¹ and Level 4^{22, 23} studies.

Kuo et al. (2013)²³ reported findings from a retrospective cohort study investigating effectiveness of a soft silicone foam dressing used for preventing skin breakdown. The study showed that the use of the soft silicone foam dressing was significantly associated with a reduction in tracheostomy site pressure ulcers in a sample of 134 pediatric individuals undergoing tracheotomies in a tertiary care pediatric hospital. The dressing was applied beneath the tracheostomy and ties. No skin breakdown developed in the dressing group as compared to the 11.8% of the comparison cohort group (p = 0.02) (Level 4 study).

In a controlled clinical trial Forni et al. (2011)²² reported a significant difference in the development of Category/Stage I heel pressure ulcers (defined as “sore skin” in the study) between a group with foam

dressing applied under the heel pad of a casted limb (n = 71) and a control group with no foam dressing under the heel pad of a casted limb (n = 85). Less than 4% of the participants receiving the foam pad to the heel developed a Category/Stage I heel pressure ulcer compared to almost 43% (p < 0.0005) in the control group, equating to a relative risk of 0.08 (95% CI 0.02 to 0.33) of developing a heel pressure ulcer when a prophylactic polyurethane foam dressing was applied. The duration for cast wearing was not reported and it was unclear if it was equivalent between the groups (Level 4 study).

The use of a silicone gel sheeting in one study was found to be effective in reducing the occurrence of nasal injuries in preterm infants receiving nasal CPAP. One randomized, controlled trial (RCT) investigated the effectiveness in preventing nasal injuries (bleeding, crusting, excoriation and columella necrosis) of using a silicone gel sheeting applied to the nares of premature neonates during nasal CPAP.²⁴ Compared to no intervention (n = 97), the prophylactic gel sheeting (n = 92) was associated with significantly fewer nasal injuries (14.9% versus 4.3%, OR = 3.43, 95% CI 1.1 to 10.1, p < 0.05) and fewer cases of columella necrosis at one month follow up (1.08% versus 6.8%, OR = 6.34, 95% CI 0.78 to 51.6, p < 0.05). Infants that developed a nasal injury had a much longer mean duration of ventilation (19.6 ± 10.6 days versus 4 ± 3.3 days), but injuries developed more rapidly in those without gel sheeting. Methods of randomization, allocation concealment and blinding were not clearly reported and the disparate duration of therapy between groups confounded the findings (Level 2 study).

In a study by Weng (2008)²¹, individuals requiring NIV received a hydrocolloid dressing to the nasal bridge prior to application of the NIV face mask. Time to occurrence of a Category/Stage I pressure ulcer was significantly increased and device related pressure ulcers were significantly reduced in individuals treated prophylactically with a hydrocolloid semipermeable dressing compared to controls (no dressing covering). In this study 40% of those treated with the prophylactic hydrocolloid dressing developed a Category/Grade I pressure ulcer compared with 96.7% in the group receiving no prophylactic dressing (p < 0.01), demonstrating an absolute risk reduction of greater than 50% (Level 3 study).

In a quasi-experimental study conducted in a pediatric unit (n = 40), Chidini et al. (2010)¹⁹ compared CPAP delivery using a face mask (various models selected as appropriate to each child) compared with an infant helmet secured with a soft neck collar. Significantly more Category/Stage I pressure ulcers were associated with the use of a face mask as compared to the helmet (75% versus 0%, p = 0.002) despite significantly shorter wear times for those in the facial mask group (6.4 ± 1.8 hours versus 10.8 ± 2.0 hours, p = 0.001) and despite the use of a prophylactic hydrocolloid dressing applied to facial pressure points beneath masks. However, of 97 potential participants, only 20 children met the selection criteria to use the CPAP helmet, indicating that practical use of the device may be limited (Level 3 study).

In a quasi-experimental study²⁰ conducted in 18 nasally intubated participants undergoing head/neck surgery, the use of a hydrocolloid dressing in combination with a soft liner made from a composite conformable material used for denture cushioning was found to be effective in reducing the rate of pressure ulcers associated with nasal intubation (60% versus 100%, p = not reported) (Level 3 study).

A study by Weng (2008)²¹ comparing a hydrocolloid semi-permeable dressing to a transparent film dressing yielded no significant differences in preventive properties between the two dressings types with respect to mean duration of time until pressure ulcer occurrence (3.6 days versus 4.5 days). Both dressings significantly increased the time to develop a Category/Stage I pressure ulcer associated with a NIV device and decreased the occurrence of these injuries compared to no prophylactic dressing. A potential mechanism for this effect is that the dressing reduced sliding of the mask on the individual's skin and reduced skin irritation caused by pressure from tight restraining straps (Level 3 study).

4.1. When selecting a prophylactic dressing consider:

- **ability of the dressing to manage moisture and microclimate, especially when used with a medical device that may be in contact with bodily fluids/drainage (e.g. percutaneous endoscopic gastrostomy tube);**
- **ease of application and removal;**
- **ability to regularly assess skin condition;**

- **thickness of the dressing under tightly fitting devices;**
- **anatomical location of the medical device; and**
- **type/purpose of the medical device. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Prophylactic dressings differ in their qualities;^{13, 25} therefore it is important to select a dressing that is appropriate to the individual and the clinical use.

A transparent film dressing is less able to contain discharge, and may not adhere to the skin as effectively as a hydrocolloid dressing.²¹ Foam dressings have greater ability to absorb moisture than film or hydrocolloid dressings.¹ Some dressings are more able to manage humidity and moisture at the skin surface than others. One laboratory study found that for some dressings, accumulation of moisture reduced the ability of the dressing to transpire.²⁵

Some dressings are designed to adhere well to the skin; however if they are not removed carefully there is increased risk of damage to fragile skin.^{13, 26, 27} Dressings with a soft silicone border may be more easily lifted for regular skin assessment, and appear to absorb shear forces more efficiently.¹³

Further discussion of the properties of prophylactic dressings is in the *Emerging Therapies for Prevention of Pressure Ulcers* section of the guideline.

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TREATMENT OF PRESSURE ULCERS

CLASSIFICATION OF PRESSURE ULCERS

Introduction

A pressure ulcer classification system is used to aid in the description of the extent of skin and tissue damage presenting as a pressure ulcer. Numerous classification systems have been developed and used over the years, informed by evolving understanding of the etiology of pressure ulcers; anatomical knowledge of skin, tissue and muscle layers; and diagnostic and assessment technology. The use of a reliable classification system:

- improves communication between health professionals,
- contributes to the development of an appropriate pressure ulcer prevention plan, including allocation of pressure redistribution support surfaces;
- informs the selection of pressure ulcer treatments;
- allows for comparison of data between institutions; and
- improves the methodological quality of pressure ulcer research.

Differential Diagnosis

1. **Differentiate pressure ulcers from other types of wounds. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Open wounds from various etiologies (e.g., venous ulcers, neuropathic ulcers, incontinence associated dermatitis, skin tears and intertrigo) may appear similar to a pressure ulcer; however, the treatment of any wound begins with comprehension of its etiology.

Hart et al. (2006)¹ reported on a study of the accuracy of nurses' assessments of pressure ulcers and other ulcers. The most difficult aspect of the classification was in the etiologies of other ulcers (e.g., neuropathic, venous, arterial and incontinence-associated dermatitis). Accuracy and reliability is reported to be low for nurses attempting to distinguish incontinence-associated dermatitis or moisture lesions from Category/Stage II pressure ulcers.^{2,3}

These findings were supported in an online survey conducted by Mahoney et al. (2011)⁴ In this study, nurses with wound certification (n = 100) classified nine photographs of gluteal cleft and buttock wounds. Presented photographs consisted of pressure ulcers, moisture lesions, incontinence-associated dermatitis and skin tears. There was an overall lack of consensus amongst nurses in identifying wound etiology ($\kappa = 0.1708$, 99% confidence interval [CI] 0.163 to 0.1786). (Level 4 study).

Pressure Ulcer Classification Systems

1. **Use the International NPUAP/EPUAP Pressure Ulcer Classification System to classify and document the level of tissue loss. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Review the Guideline Development Group statement on the 2016 release of the NPUAP Pressure Injury Staging System at: http://internationalguideline.com/statements#staging_system_revision

This recommendation is based on expert opinion. Pressure ulcers are classified according to the amount of visible tissue loss. The EPUAP and NPUAP pressure ulcer classification systems are the most commonly used systems. In 2009, these two systems were amalgamated to create the International NPUAP/EPUAP Pressure Ulcer Classification System published in this guideline.


Little comparative data exists on the accuracy of different pressure ulcer classification systems. Generally a specific health care system tends to use a single pressure ulcer classification system. Russell et al. (2001)⁵ examined the accuracy and precision of diagnostic labeling of ulcers, comparing health

professionals' level of training and accuracy using two staging systems (the EPUAP system and the full four digit Stirling classification tool). Lower levels of disagreement occurred when the EPUAP system was used (Level 3 study).

Pressure ulcer classification is based on the visual or palpatory identification of tissues including skin, subcutaneous fat, bone, muscle, tendon, and ligament. Necrotic tissue (slough and eschar) appears in full-thickness pressure ulcers. Granulation tissue becomes present as full-thickness ulcers heal. In contrast, Category/Stage II pressure ulcers do not have necrotic tissue and heal with epithelialization rather than granulation tissue. Healing tissues include scar, granulation tissue, and epithelium.

Pressure ulcer depth varies by anatomical site, and relying on depth alone to determine whether an ulcer is Category/Stage III or IV can be misleading. In body areas with little adipose tissue, such as the bridge of the nose, the occiput, behind the ear, the sacrum, and the malleolus, shallow ulcers can be Category/Stage IV pressure ulcers. In contrast, in body areas with greater adipose tissue, such as the buttocks and ischium, a pressure ulcer may be deep but not reach the muscle or bone, and therefore would remain a Category/Stage III pressure ulcer.

The description of a pressure ulcer should be supplemented with other findings. Indicating the exact location of the pressure ulcer is important, making clear reference to bony prominences if the pressure ulcer is over a bony prominence. Historical information, such as the conditions under which the ulcer began, the history of prior treatment, and the trajectory of healing or non-healing of the ulcer (if known) should be communicated and documented. Such information helps health professionals to evaluate the effectiveness of later treatments.

- 2. Rely on assessment of skin temperature, change in tissue consistency and pain rather than identification of nonblanchable erythema when classifying Category/Stage I pressure ulcers and suspected deep tissue injury in individuals with darkly pigmented skin. (Strength of Evidence = C; Strength of Recommendation = )**

Category/Stage I pressure ulcers and suspected deep tissue injury (SDTI) may be difficult to detect with visual inspection alone in dark skinned individuals.

A higher proportion of full-thickness ulcers in dark skinned individuals suggests that detection and treatment are delayed until full-thickness injury is apparent. Vangilder, McFarlane and Meyer⁶ reported on an international pressure ulcer prevalence study that included data on ulcer categories and skin tones (light, medium, and dark). The number of Category/Stage I pressure ulcers was proportionately lower in individuals with dark skin tones (13%) in comparison to those with medium skin tones (32%) and light skin tones (38%). Category/Stage III and IV pressure ulcers were found at proportionately higher rates in individuals with darker skin pigmentation. There was little difference in the percent of Category/Stage II pressure ulcers by skin tone: 36.8% for light tones, 39.3% for medium tones and 41.3% in those with dark toned skin. However, there was a greater percent of Category/Stage III and IV pressure ulcers in individuals with dark skin tone: 6.2% of light toned subjects and 6.7% of those with medium toned skin had Category/Stage III ulcers, compared to 10.8% of individuals with dark skin tones. A similar pattern is seen in Category/Stage IV pressure ulcers: 5.5% of light toned subjects, 6.8% of those with medium skin tones and 12.9% of those with dark toned skin (Level 4 study). This pattern is a recurrent trend in pressure ulcer prevalence and incidence studies.⁷⁻¹¹ Astute assessment of intact skin in dark skinned individuals is critical in reversing this trend.

In a study of 1,938 residents of 59 nursing homes, Baumgarten et al. (2004)¹² reported a significantly higher rate of Category/Stage II to IV pressure ulcers for residents with dark skin tones (0.56 ulcers per person year) compared with residents with light skin tones (0.35 ulcers per person year) ($p < 0.001$). Race was significantly associated with pressure ulcer development in a multivariate analysis that also considered resident and facility characteristics (Level 4 study). Rosen et al. (2006)¹³ found similar disparities between dark and light skin toned nursing home residents at the beginning of a quality improvement program. Staff education and incentives eliminated the racial disparities noted at baseline (Level 3 study).

- 3. Assess skin heat, tenderness, change in tissue consistency and pain to assist in identifying the severity of Category/Stage II to IV and unstageable pressure ulcers in individuals with darkly pigmented skin. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is based on expert opinion. Just as Category/Stage I pressure ulcers and deep tissue injury in intact skin may go undetected in dark skinned individuals,⁶⁻¹³ the full extent and severity of open pressure ulcers may be overlooked without a full assessment of the surrounding skin. Inflammatory redness from cellulitis and deeper tissue damage may be difficult to detect in individuals with darkly pigmented skin, therefore diagnosis of cellulitis and/or identification of undermining may be delayed or missed. Assess skin heat, pain or change in tissue consistency to identify the extent of inflammation and possible cellulitis and/or undermining in Category/Stage II, III, IV and unstageable pressure ulcers.

Evidence suggests that individuals with Category/Stage IV pressure ulcers experience more pain than individuals with lower Category/Stage ulcers.¹⁴⁻¹⁶

- 4. Use the International NPUAP/EPUAP Pressure Ulcer Classification System to classify and document the level of tissue loss in medical device related pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is based on expert opinion. Medical device related pressure ulcers are pressure ulcers that result from the use of devices designed and applied for diagnostic or therapeutic purposes. The resultant pressure ulcer generally closely conforms to the pattern or shape of the device.¹⁷

Medical device related pressure ulcers should be classified according to the amount of visible tissue loss using the International NPUAP/EPUAP Pressure Ulcer Classification System, as for most other pressure ulcers.

- 5. Do not use the International NPUAP/EPUAP Pressure Ulcer Classification System to describe tissue loss in wounds other than pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This recommendation is based on expert opinion. Pressure ulcer classification systems should only be used to document tissue loss in ulcers resulting from pressure or pressure in combination with shear. Other staging systems exist that can be used to describe venous ulcers, diabetic (neuropathic) ulcers and skin tears.

- 6. Do not categorize/stage pressure ulcers on mucous membranes. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is based on expert opinion. Mucosal pressure ulcers are pressure ulcers found on mucous membranes with a history of medical device use at the location of the ulcer. Where pressure is a significant factor in the etiology of the wound, it should still be considered to be a pressure ulcer; however, it is inappropriate to use a pressure ulcer classification system to categorize/stage the ulcer.

Mucous membrane is the moist lining of body cavities that communicates with the exterior. These tissues line the tongue, gastrointestinal tract, nasal passages, urinary tract and vaginal tract. Pressure applied to this tissue can render it ischemic and lead to ulceration. Mucosal tissues are especially vulnerable to pressure from medical devices, such as oxygen tubing, endotracheal tubes, bite blocks, orogastric and nasogastric tubes, urinary catheters, and fecal containment devices.

The classification system for pressure ulcers of the skin cannot be used to categorize mucosal pressure ulcers. Nonblanchable erythema cannot be seen in mucous membranes, shallow open ulcers indicating superficial tissue loss of the non-keratinized epithelium are so shallow that the naked eye cannot distinguish them from deeper, full-thickness ulcers. Soft coagulum seen in mucosal pressure ulcers, which looks like slough often present in Category/Stage III pressure ulcers, is actually soft blood clot. Exposed muscle would seldom be seen, and bone is not present in these soft tissues.

7. Verify that there is clinical agreement in pressure ulcer classification amongst the health professionals responsible for classifying pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = B)

A number of published studies have examined the clinical agreement in pressure ulcer identification and categorization/staging. These studies have either compared bedside evaluations of wounds or evaluated assessments of wounds from photographs. Nixon et al. (2005)¹⁸ reported on a study of pressure ulcer assessment between general registered nurses and wound nurses. In addition to the usual categories/stages of pressure ulcers, a classification for blanching or nonblanching was also included. Interrater reliability was high; there were 21% disagreements, and 82% of those disagreements fell within one Category/Stage (Level 3 study).

Bours et al. (1999)¹⁹ compared nurses' and wound care experts' bedside assessments of pressure ulcer classification in a variety of healthcare settings. The nurses in the hospital (674 observations on 45 individuals) and nursing home (344 observations on 23 individuals) had near perfect interrater reliability ($\kappa = 0.97$ and $\kappa = 0.81$), but interrater reliability was lower in the home care setting (1,348 observations on 90 individuals, $\kappa = 0.49$). In all three settings, less than 1% of the observations resulted in classification as a Category/Stage III or IV pressure ulcer, and the vast majority (up to 97%) in each health care setting identified no pressure ulcer present. Most disagreement was between no pressure ulcer present and Category/Stage I pressure ulcer present (Level 3 study).

Use of photographs is a common method of teaching and testing knowledge of different Categories/Stages of pressure ulcer. Defloor and Schoonhoven^{2,3} examined the interrater reliability of pressure ulcer identification and staging performed by 44 pressure ulcer experts. Photographs of 48 pressure ulcers, along with photographs of eight incontinence-associated dermatitis sites (also reported as moisture lesions), were assessed. Kappa (κ) values ranged from 0.64 to 0.75, indicating moderate to substantial agreement in pressure ulcer identification and category/staging between pressure ulcer expert raters. Incontinence as an etiology of pressure ulcers was a common area of misclassification (Level 3 study).

Bergquist-Beringer et al. (2011)²⁰ investigated interrater reliability of classification performed by direct observation and by reviewing photographs. Participants ($n = 180$) performed their direct observation classifications in teams, all observing the individual pressure ulcer ($n = 591$) at the same time but remaining blind to other team members' classifications. After the direct observation phase, participants performed web-based classification of photographs, with half the participants randomized to receive a short description of the wound alongside the photograph, and the other half receiving only the photograph. Interrater reliability was moderate for classification using direct observation. For Category/Stage I to IV pressure ulcers κ was 0.60 and for classification of Category/Stage II to IV and unstageable pressure ulcers κ was 0.61. Interrater reliability was slightly better for classification via photographs ($\kappa = 0.69$) (Level 2 study).

In a study that included individuals with both light ($n = 28$) and darker ($n = 20$) skin tones, Baumgarten et al. (2009)²¹ compared real time clinical assessment performed by a wound care specialist with digital photography assessed by blinded dermatologists and wound care specialists as strategies to classify pressure ulcers. Digital photography had an overall high sensitivity (97%) for classifying pressure ulcers of Category/Stage II or greater, with slightly lower sensitivity in individuals with darker skin tones (93%) (Level 3 study).

In a cross-sectional study conducted by Bååth et al. (2008)²² the interrater reliability of pressure ulcer classifications performed using the Pressure Ulcer Card (PUC) was investigated. The PUC included descriptions and color illustrations of pressure ulcer categorized into four Classifications/Stages (an additional Classification/Stage was also added for intact skin). Registered nurses (RNs) and enrolled nurses (ENs) performed skin assessments as a team, each conducting an independent assessment within one hour of each other. A second team performed an additional assessment within two hours of the first assessment. Interrater reliability was moderate among the RNs ($n = 114$ assessments, $\kappa = 0.364$ to 0.637 by anatomical location), moderate among the ENs ($n = 114$ assessments, $\kappa = 0.322$ to 0.607 by

anatomical location) and moderate between the RNs and the ENs (n = 228 assessments, κ = 0.394 to 0.755 by anatomical location). Interrater reliability was highest for assessment of the sacral region. The study did not report the outcome of Category/Staging assessments, but implied that the majority of assessments identified intact skin of Category/Stage I pressure ulcers (Level 4 study). Higher levels of education and training in wound care are generally associated with more accurate assessments of the Category/Stage. Briggs (2006)²³ conducted a pre- and post-test study in pressure ulcer classification. The study concluded that the level of accuracy of pressure ulcer classification was poor pre-test but markedly improved post-test (Level 3 study). Young et al. (2011)²⁴ also found that classification using a clinical decision tool to assist clinical decision making improved following education for both health professional (correct responses pre-education 63.5% versus 70.7% post-education) and for students (52.3% versus 67%) (Level 3 study).

Hart et al. (2006)¹ found that accuracy of nurses without training in wound care could reach that of wound nurses if the wound descriptions were included along with the photographs. However, in study by Young et al. (2011)²⁴ classifications performed by students did not reach the accuracy of those performed by health professionals when using a tool that included both descriptions and indicative photographs (Level 3 study). In the study by Bergquist-Beringer et al. (2011)²⁰, there was much stronger interrater reliability for classification using photographs when a short description was included (κ = 0.81) compared with providing the photograph only (κ = 0.59). When provided with a decision tree to classify three pressure ulcers and choose treatments, the accuracy of classification did not improve, but the choice of dressings did²⁵ (Level 3 study).

Sarhan (2010)²⁶ also found high interrater agreement between nurses (n = 10) using good quality images to classify pressure ulcers in individuals with spinal cord injury. There was 100% agreement in classification using the EPUAP framework for Category/Stage I and II pressure ulcers and 77% agreement for Category/Stage IV pressure ulcers (Level 4 study).

Two recent studies^{24, 27} explored the use of digital clinical decision support systems that can be used by the health professional as an aid to classifying pressure ulcers.

The small study by Alvey et al. (2012)²⁷ had methodological limitations and failure of the digital system to operate as expected during the study indicated that the system requires improvements before it could be adopted in clinical practice. Young et al. (2011)²⁴ investigated the intrarater reliability of the N.E. One Can Stage digital system that was designed to assist in accurate category/staging conducted by both health professionals and students (n = 101). The tool includes descriptions of pressure ulcer Categories/Stages, indicative photographs and a measurement scale that can be used to calculate the wound margins of a photographed pressure ulcer. In this study, participants identified and then classified photographs of eight pressure ulcers and two other wound types. Participants repeated the assessment four times, each with varying levels of education on pressure ulcer classification and tool use. There was substantial reliability between tests three and four (intraclass coefficient [ICC] = 0.794, 95% CI 0.697 to 0.862). Although the intrarater reliability was substantial, the study did not investigate use of the tool as it was intended, i.e., health professionals were presented with photographs rather than taking photographs of pressure ulcers and aligning them correctly with the in-built measurement tool. This tool has been updated since the study was published (now called NE1 Wound Assessment Tool) (Level 3 study).

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ASSESSMENT OF PRESSURE ULCERS AND MONITORING OF HEALING

Introduction

Comprehensive assessment of the individual and his or her pressure ulcer informs development of the most appropriate management plan and ongoing monitoring of wound healing. Effective assessment and monitoring of wound healing is based on scientific principles, as described in this section of the guideline.

Assessment of the Individual with a Pressure Ulcer

1. **Complete a comprehensive initial assessment of the individual with a pressure ulcer. An initial assessment includes:**

- **Values and goals of care of the individual and/or the individual's significant others.**
- **A complete health/medical and social history.**
- **A focused physical examination that includes:**
 - **factors that may affect healing (e.g., impaired perfusion, impaired sensation, systemic infection);**
 - **vascular assessment in the case of extremity ulcers (e.g., physical examination, history of claudication, and ankle-brachial index or toe pressure); and**
 - **laboratory tests and x-rays as needed.**
- **Nutrition.**
- **Pain related to pressure ulcers.**
- **Risk for developing additional pressure ulcers.**
- **Psychological health, behavior, and cognition.**
- **Social and financial support systems.**
- **Functional capacity, particularly in regard to repositioning, posture and the need for assistive equipment and personnel.**
- **The employment of pressure relieving and redistributing maneuvers.**
- **Resources available to the individual (e.g. pressure redistribution support surfaces).**
- **Knowledge and belief about prevention and treatment of pressure ulcers.**
- **Ability to adhere to a prevention and management plan. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Assessment of the individual, his or her ability to heal, the risk for development of additional pressure ulcers, and the ulcer itself are important. An assessment of the individual should include any co-morbid health problems, including combination(s) of problems; medications; nutritional status; risk factors, including immobility and incontinence; diagnostic test results; psychosocial implications; and wishes, goals and concerns of the individual and significant others.¹⁻⁹

Grubbs et al. (2009)¹⁰ explored the predictive value of high frequency ultrasound in early identification of pressure ulcers in a cohort of older adults at high risk. The randomized controlled trial (RCT) failed to demonstrate that high frequency ultrasound was an effective strategy for predicting the development of Category/Stage I pressure ulcers of the heel or sacrum compared with a focused physical assessment (Level 2 study).

Comprehensive recommendations and guidance on specific areas of patient assessment are outlined in other sections of this guideline including:

- *Pain Assessment and Management,*
- *Nutrition in Pressure Ulcer Prevention and Treatment,*
- *Risk Factors and Risk Assessment,*
- *Repositioning and Early Mobilization,*
- *Assessment and Treatment of Infection and Biofilms, and*
- The guideline sections for special populations.

Assessment of the individual also includes an assessment of the environment and resources that will influence the individual's ability to heal. The *Support Surfaces* section of the guideline provides detailed recommendations on assessing the individual's need for and availability of appropriate support surfaces.

2. Reassess the individual, the pressure ulcer and the plan of care if the ulcer does not show signs of healing as expected despite appropriate local wound care, pressure redistribution, and nutrition. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

2.1. Expect some signs of pressure ulcer healing within two weeks. (Strength of Evidence = B; Strength of Recommendation = 👍)

2.2. Adjust expectations for healing in the presence of multiple factors that impair wound healing. (Strength of Evidence = B; Strength of Recommendation = 👍)

If progress toward healing is not seen within two weeks, the individual, the pressure ulcer, and the plan of care should be re-evaluated. General signs of healing include decreased length, width, and depth of the ulcer; progressively less exudate; and changes in tissue type from less devitalized tissues (e.g., eschar and slough) to healthy regenerative tissues (e.g., granulation tissue and epithelialization). The health professional should be particularly alert to these signs when making a clinical judgment regarding the healing progress of the pressure ulcer.

Several investigators have analyzed data from large databases to address the question of how long it takes for a pressure ulcer to heal.^{11, 12} However, no definitive answers have emerged because the contextual variables affecting healing vary from study to study, just as they do from individual to individual. Healing rates and outcomes vary according to a myriad of factors, including:

- initial size and Category/Stage of the ulcer,¹³⁻¹⁵
- presence or absence of infection,¹⁶
- adequacy of the treatment plan in relation to the current assessment of the ulcer,^{11, 15}
- co-morbidities, and
- nutritional status^{12, 17} (Level 3 studies).

In a 15-month longitudinal study of individuals with pressure ulcers (n = 119 individuals with 153 ulcers), van Rijswijk (1993)¹⁴ noted that ulcers that did not show at least a 45% reduction in size at two weeks or a 77% reduction at four weeks were less likely to heal during the study. In this study the pressure ulcers were treated with 3% hydrogen peroxide, saline rinse and a hydrocolloid dressing. Pressure redistribution support surfaces and repositioning were only used for those individuals that had already received such interventions prior to study enrolment (Level 3 study).

Category/Stage II pressure ulcers take less time to heal than Category/Stage III and IV ulcers. Lynn et al. (2007)¹⁸ reported that the median days to healing of Category/Stage II pressure ulcers in nursing home residents was 51 to 52 days. However, the analysis only included ulcers that had persisted for 30 days; Category/Stage II ulcers that healed more quickly were not included (Level 4 study). In a multi-site retrospective study of 774 nursing home residents with Category/Stage II pressure ulcers Bergstrom et al. (2008)¹⁹ reported median time to healing as 46 days. The initial size of the ulcer was significantly associated with median days to healing (i.e., 33 days for small [≤ 1 cm²], 53 days for medium [> 1 to 4 cm²], and 73 days for large [> 4 cm²] ulcers) (Level 4 study).

Mean times to healing were about twice as long for full-thickness (Category/Stage III and IV) pressure ulcers than for partial-thickness (Category/Stage I and II) pressure ulcers in a 12-week study of chronic wounds.¹¹ Lynn et al. (2007)¹⁸ reported 140 to 150 days as median time to healing for nursing home residents with Category/Stage III and IV pressure ulcers, although this analysis only includes the few full-thickness ulcers that did heal during the study reporting period (Level 4 study). In a 1990 study of 19,889 residents of 51 nursing homes conducted over a 2-year period, Brandeis et al. (1990)²⁰ reported that the largest increment in healing occurred in the first three months, with 31.5% of Category/Stage III and 23.3% of Category/Stage IV ulcers healing within

that time frame (Level 5 study). In 2004, using standardized assessment and advanced treatment protocols, Bolton et al. (2004)¹¹ reported that 36% of 373 Category/Stage III and IV pressure ulcers healed during the 12-week study period, with an average healing time of 62 days (\pm 54 days) (Level 5 study).

3. Teach the individual and his or her significant others about:

- the normal healing process,
- how to identify signs of healing or deterioration, and
- signs and symptoms that should be brought to the health professional's attention. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This recommendation is based on expert opinion. An understanding of the prevention and treatment of pressure ulcers and factors that influence healing allows the individual to meaningfully contribute to his or her healthcare, including alerting the health professional to signs and symptoms of wound deterioration.^{21, 22} The *Patient Consumers and Their Caregivers* section of the guideline provides recommendations on patient education and ongoing involvement in pressure ulcer prevention and management.

Pressure Ulcer Assessment

1. Assess the pressure ulcer initially and re-assess it at least weekly. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

1.1. Document the results of all wound assessments. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

A two-week period is recommended for evaluating progress toward healing. However, weekly assessments provide an opportunity for the health professional to assess the ulcer more regularly, detect complications as early as possible, and adjust the treatment plan accordingly.

2. With each dressing change, observe the pressure ulcer for signs that indicate a change in treatment is required (e.g., wound improvement, wound deterioration, more or less exudate, signs of infection, or other complications). (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Wound status can change rapidly. Wound improvement or deterioration indicated by change in wound dimensions, change in tissue quality, an increase or decrease in wound exudate, signs of infection or other complications all provide indications of the effectiveness of the current management plan. The person responsible for dressing changes should be educated regarding signs and symptoms of complications that should be reported to the health professional. The *Assessment and Treatment of Infection and Biofilms* section of the guideline provides more information on signs and symptoms associated with pressure ulcer infection.

A longitudinal study by Edsberg et al. (2011)²³ investigated strategies to predict wound healing times. Participants were seen every day for ten days then weekly until study end (42 days). Findings identified that ulcer size at day 0 was a significant predictor of time to heal ($p = 0.023$), with smaller wounds taking less time to heal. Average daily healing was positively correlated with initial wound size ($p = 0.3537$). While percent area measurements are considered the easiest to determine, this measurement is sensitive to initial wound size. Linear healing rate is a reliable indication of healing. A four-week response time with regular recording of a validated wound measurement achieves a reliable indicator of response to care.

2.1. Address signs of deterioration immediately. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This recommendation is based on expert opinion. Signs of deterioration (e.g., increase in wound dimensions, change in tissue quality, increase in wound exudate or other signs of clinical infection

(see the *Assessment and Treatment of Infection and Biofilms* section of the guideline) should be addressed immediately.

Where the goal of care is to achieve pressure ulcer healing, management should be re-evaluated if there are no indications of progress toward healing within two weeks of initiating an appropriate wound management plan and a pressure care plan. The *Special Populations: Individuals In Palliative Care* section discusses ongoing management in cases where healing the wound is not a primary goal of care.

3. Assess and document physical characteristics including:

- location,
- Category/Stage,
- size,
- tissue type(s),
- color,
- periwound condition,
- wound edges,
- sinus tracts,
- undermining,
- tunneling,
- exudate, and
- odor. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

4. For Category/Stage II to IV and unstageable pressure ulcers in individuals with darkly pigmented skin, prioritize assessment of the following characteristics:

- skin heat,
- skin tenderness,
- change in tissue consistency, and
- pain. (Strength of Evidence = C; Strength of Recommendation = 👍)

This recommendation is based on expert opinion. Inflammatory redness from cellulitis and deeper tissue damage may be difficult to detect in individuals with darkly pigmented skin. Just as Category/Stage I pressure ulcers and deep tissue injury in intact skin may go undetected in dark skinned individuals,²⁴⁻³¹ the full extent and severity of open pressure ulcers may be overlooked without a full assessment of the surrounding skin (or where this is not possible or clear, the skin on the opposite side of the body). Diagnosis and treatment of cellulitis and/or undermining may be delayed or missed. Warm, firmer skin that is tender or painful may indicate infection, cellulitis or undermining/tunneling in the adjacent pressure ulcer.

Nakagami et al. (2010)³² utilized thermography to predict pressure ulcer healing. In this small study (n = 33), the relative risk for delayed healing in pressure ulcers with a wound temperature above the temperature of surrounding skin was 2.25 (95% confidence interval [CI] 1.13 to 4.47, p = 0.021). The study was of only three weeks duration and the sensitivity of the thermography in detecting pressure ulcers that would be slow to heal was 0.56. In a second trial, the research team combined thermography with ultrasound, reporting a sensitivity of 0.69 and specificity of 0.71 in predicting progression from Category/Stage I pressure ulcer to classification as a deep tissue injury³³ (Level 4 studies). Although not explicitly used to assess individuals with darkly pigmented skin, the population was of Asian background, and further development of such thermographic imaging may prove useful in aiding pressure ulcer assessment in dark skinned individuals.

5. Position the individual in a consistent neutral position for wound measurement. (Strength of Evidence = C; Strength of Recommendation = 👍)

This recommendation is based on expert opinion. It is possible to distort soft tissue with variations in positioning yielding a larger or smaller measurement depending on position of the individual. For example, it may be helpful to note that a sacral ulcer was measured with the individual turned at a 90°

angle on his/her left hip with legs extended. Leg flexion and variations in the turning angle can distort tissue and result in very different measurements.

- 6. Select a uniform, consistent method for measuring wound length and width or wound area to facilitate meaningful comparisons of wound measurements across time. (Strength of Evidence = B; Strength of Recommendation = 👍)**

The manual measurement technique that yields the least overestimation for various wound shapes is to measure the longest length of the ulcer head-to-toe, and longest width side-to-side, perpendicular (at 90°) to the length³⁴ (Level 5 study). Measuring the longest length of the ulcer (regardless of orientation) and a perpendicular width is more sensitive in monitoring wounds with changing shapes and configurations; however, this method increases the risk of overestimation, and potentially introduces variability in the selection of the longest length.

Acetate tracings and planimetry measurements of wound area tend to provide more accurate measurements of irregularly shaped wounds; however, this method is more labor intensive.

One electronic method of wound tracing has shown good reliability under appropriate conditions.^{35, 36} Haghpanah et al. (2006)³⁵ compared two different electronic data collection systems (Visitrak™ and a digital system that is no longer available) to manual linear measurement using a disposable paper ruler in 40 different pressure ulcers. The Visitrak™ system requires the clinician to trace the wound using transparent tracing paper, after which the wound tracing is placed on the Visitrak™ tablet and retraced. The electronic tracing system was found to be more reliable in repeated measures than linear measurement (Level 4 study). In a second study, Sugama et al. (2007)³⁶ investigated the reliability of the Visitrak™ system. Four nurses used the system to perform wound tracings on ten pressure ulcers for investigation into the reliability. Both interrater and intrarater reliability were almost perfect ($r = 0.99$). The validity of measures was also investigated using comparison with digital planimetry calculated from a photograph for 30 pressure ulcers. There was a significant positive correlation between Visitrak™ wound tracings and digital planimetry ($r = 0.99$, $p < 0.001$) (Level 4 study).

For clinical practice, a method that balances validity, reliability, and clinical utility should be selected and consistently used. For research purposes, a more labor intensive but precise technique may be desirable.

- 7. Select a consistent, uniform method for measuring depth. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Caution: Care should be taken to avoid causing injury when probing the depth of a wound bed or determining the extent of undermining or tunneling.

This recommendation is based on expert opinion. Measurement of pressure ulcer depth and measurement of areas of tunneling and undermining are typically performed through the very gentle insertion of a pre-moistened (with normal saline or sterile water) cotton-tipped applicator to the gentle point of resistance. The applicator is then marked off at the point that it meets skin level, then removed and held alongside a ruler to determine depth measurement in centimeters.

- 8. Consider further diagnostic investigations of wound bed tissue when healing does not progress. (Strength of Evidence = C; Strength of Recommendation = 👍)**

In some cases tissue biopsies can improve understanding of the healing process and potential for healing. Differential expression levels of specific wound proteins assayed by mass spectrometry and multiplexed microassays are predictive of healing in the wound. In a longitudinal study, Edsberg et al. (2012)³⁷ identified significant differences in levels of 21 wound proteins in various parts (periphery versus interior) of the wound tissue between chronic pressure ulcers and those that healed (Level 4 study).

- 9. Use the findings of a pressure ulcer assessment to plan and document interventions that will best promote healing. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

9.1. Reevaluate the pressure ulcer assessment plan if the pressure ulcer does not show signs of healing within two weeks. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

The treatment needs of a pressure ulcer change over time, in terms of both healing and deterioration. Treatment strategies should be continuously re-evaluated based on the current status of the ulcer.

Where the goal of care is to achieve pressure ulcer healing, treatment should be re-evaluated if there are no indications of progress toward healing within two weeks of initiating an appropriate wound management plan and a pressure care plan. Adjust the timeframe for expected healing according to the individual's overall clinical status. The *Special Populations: Individuals In Palliative Care* section discusses ongoing management in cases where healing the wound is not a primary goal of care.

Methods for Monitoring Healing

Currently in clinical practice pressure ulcers are monitored using the clinical judgment of a health professional supported by pressure ulcer assessment tools and digital photography. In some clinical settings, digital data collection devices are becoming available.


1. Assess progress toward healing using a valid and reliable pressure ulcer assessment scale. (Strength of Evidence = B; Strength of Recommendation = 👍)

Numerous pressure ulcer assessment scales/tools have been designed to aid in assessing the progress of pressure ulcer healing, including the Bates-Jensen Wound Assessment Tool (BWAT), the Pressure Ulcer Scale for Healing (PUSH®), the Pressure Sore Status Tool (PSST) and DESIGN/DESIGN-R.

The BWAT is a 15-item tool with 13 wound characteristics scored using a Likert scale and an additional two unscored items. The detailed wound assessment data provided by the BWAT can be used as a basis for treatment decisions. The BWAT score correlates with the severity of the wound, with higher scores indicating more severe wounds. The BWAT has been used as a standardized assessment and treatment protocol that showed favorable results in healing chronic wounds.¹¹ The BWAT has undergone content and concurrent validation³⁸ and clinical evaluation.¹¹ Interrater reliability among health professionals was 0.78, and intrarater reliability was 0.89³⁸ (Level 3 study); inter-item correlation has also been examined³⁹ (Level 4 study).


The PUSH tool was developed by the National Pressure Ulcer Advisory Panel (NPUAP) as an alternative to reverse staging and as a method of monitoring healing ulcers. Using existing research databases, a principal components analysis was conducted to determine the factors most predictive of pressure ulcer healing or deterioration. Three factors (length by width, exudate amount, and predominant tissue type) explained 55 to 65% of the variance at weeks 0 through 8 for the study sample, with good discrimination between time points⁴⁰ (Level 5 study). In a study by Hon et al. (2010)⁴¹ PUSH tool scores correlated well with wound tracings ($r = 0.63$, $p = 0.01$), supporting the results of⁴⁰ (Level 4 study). The PUSH tool does not provide adequate information to serve as a basis for a comprehensive treatment plan. However, it does provide an efficient mechanism for monitoring whether the ulcer is deteriorating or improving over time and it has been successfully used in research studies to measure healing outcomes.^{18, 42-44}

The DESIGN (and revised version, DESIGN-R) is a tool developed in Japan for classifying pressure ulcer severity and monitoring healing. It has evidenced good interrater reliability (0.91 for clinical assessments and 0.98 for assessment based on photos), and shows a high correlation with PSST scores⁴⁵ (Level 5 study). A positive change of at least one point in DESIGN-R score is significantly associated with complete wound healing within 30 days⁴⁶ (Level 2 study). The DESIGN-R also has good interrater reliability (interclass coefficient [ICC] = 0.960) and a high correlation with BWAT scores⁴⁷ (Level 4 study).

2. **Use clinical judgment to assess signs of healing such as decreasing amount of exudate, decreasing wound size, and improvement in wound bed tissue. (Strength of Evidence = C; Strength of Recommendation = )**

Experienced health professionals are often astute in monitoring progress toward healing in wounds; however, there is room for variability when multiple health professionals are evaluating the pressure ulcer over time. George-Saintilus et al. (2009)⁴⁸ found poor correlation between clinical judgment of health professionals and PUSH tool scores ($\kappa = 0.11$ to 0.32) in the assessment of 48 individuals (370 total assessments) with Category/Stage II to IV pressure ulcers. Considering the strong correlations that have been established between PUSH scores and objective outcomes (e.g., wound tracings),^{40, 41} the study suggests caution should be taken when relying on only clinical judgment to assess wound progress.

When relying on clinical judgment to assess progress toward healing, there should be clear documentation and ongoing communication among the various health professionals providing care for the individual.

3. **Consider using baseline and serial photographs to monitor pressure ulcer healing over time. (Strength of Evidence = C; Strength of Recommendation = )**

Some health professionals choose to use serial photographs as a method of monitoring pressure ulcer progress. Photographs should not replace bedside assessment, but may serve as a useful documentation strategy. If used, photographic techniques and equipment should be standardized to ensure accurate representation of the pressure ulcer condition that can be reliably compared over time. For example, Sprigle et al. (2011)⁴⁹ found that the accuracy of digital wound photography was influenced by angle skew, especially when assessing wound dimensions. Errors of approximately 4% with a 10° angle skew were noted in this small trial.

Davis et al. (2013)⁵⁰ compared three dimensional (3D) wound imaging performed by wound experts and registered nurses to independently performed clinical assessments. Assessment of improvement based on viewing the 3D images significantly correlated with objective assessment of wound diameters and surface area ($p < 0.01$); however, attainment of a readable 3D image was only achieved in about half the pressure ulcer assessments and was lower for the registered nurses than the wound experts.

In their study comparing digital photography to use of a standard wound assessment form that included wound descriptors, wound dimensions, exudate and wound bed assessments, Terris et al. (2011)⁵¹ established interrater agreement of 50% for digital photography ($n = 31$ assessments). Agreement when one nurse used digital photography and a second nurse used the standard wound assessment form was only 38.5%. Digital photography was considered labor intensive in this trial (Level 3 study).

Recent Research in Pressure Ulcer Assessment and Monitoring

Recent research on pressure ulcer assessment has included investigation into the role of digital assessment of the redness value of wounds. Iizaka et al. (2013)⁵² have undertaken pilot studies validating various measures for wound redness and have promising outcomes. However, this research is currently not feasible in most clinical settings.

Recent research into strategies to monitor pressure ulcer healing has also investigated the use of ultrasound. Two small studies by the same research team exploring the role of ultrasound produced findings indicating that characteristics of the fascia and deep tissue that are detectable using ultrasound may predict deterioration of a pressure ulcer versus its healing. Although promising, these techniques are in their infancy and are not routinely used in clinical practice to monitor pressure ulcers.^{53, 54}

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PAIN ASSESSMENT AND TREATMENT

Introduction

Pressure ulcers are painful. Individuals with pressure ulcers experience ulcer related pain that can be quantified and differentiated from other pain, and this pain occurs both during procedures and at rest. Dallam et al. (1995)¹ evaluated pressure ulcer pain in 132 hospitalized adults with Category/Stage I or II pressure ulcers. Using a visual analog scale (VAS) or the Faces Rating Scale (FACES) scale, researchers were able to demonstrate that those participants who could respond (n = 44) could quantify their pressure ulcer pain. The average Category/Stage I and II pressure ulcer pain reported was 4 cm and 3.5 cm on a 10cm VAS, respectively. Individuals with Category/Stage IV pressure ulcers had greater pain than those with lower Category/Stage ulcers. In all, 68% of those who responded reported some degree of pressure ulcer pain. However, only 2% of those individuals reporting pressure ulcer pain received timely analgesics after complaints of pain (Level 3 study).

Gorecki et al. (2011)² concurred with these findings in their systematic review (four quantitative studies and six qualitative studies) involving participants with pressure ulcer pain (n = 108). Participants with Category/Stage II pressure ulcers reported lower pain severity than those with Category/Stage III and IV pressure ulcers. The outcome of the work by Gorecki et al. (2011)² is a conceptual framework of five pain domains: communicating the pain, feeling the pain, impact of pain, self-management, and professional management.

The pain caused by pressure ulcers can be constant and severe, and may be the most distressing pressure ulcer symptom the individual reports.^{1, 3-20} Pain related to pressure ulcers can arise from:

- pressure, friction, and/or shear;
- damaged nerve endings;
- inflammation;
- infection;
- procedures/treatments; or
- excoriation from incontinence and muscle spasm.²¹⁻²³

Pressure ulcer pain can occur at rest, when no procedures are being performed.^{4, 8, 11, 17, 18}

A prevalence study conducted in long term aged care facilities in seven European countries (n = 4,156) found that presence of a severe pressure ulcer (odds ratio [OR] = 2.03, 95% confidence interval [CI] 1.51 to 2.72, p < 0.01) was a significant correlate in the experience of pain.²⁴ Individuals with Category/Stage IV pressure ulcers experience more pain than individuals with lower Category/Stage ulcers.^{1, 11, 16}

Pressure ulcer related pain may be acute (including hyperalgesia), chronic, or neuropathic. Refer to the *Glossary* for definitions and further explanation.

Assess for Pressure Ulcer Pain

Data gathered during a pain assessment measures pressure ulcer pain presence, quality and quantity. These data are interpreted to determine the severity of pressure ulcer pain and inform the development of an appropriate management plan.

1. **Assess all individuals for pain related to a pressure ulcer or its treatment and document findings. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

The most reliable indicator of pain is the individual's report of pain. Systematic ongoing assessment of pain provides direction for the pain treatment plan, with modifications based on the response of the individual.^{20, 21, 25} In fact, the U.S. Joint Commission on Accreditation of Hospital Organizations mandates regular and ongoing assessment of pain in all hospitalized individuals in US health facilities.²⁶

Pain assessments should be done prior to and during wound procedures, such as dressing changes or debridement, as well as when the dressing is intact and no procedures are in progress.

The assessment for pressure ulcer pain needs to be comprehensive, including objective and subjective assessment. An initial pain assessment should include the following four elements:

- a detailed pain history including the character, intensity and duration of pressure ulcer pain;
- a physical examination that includes a neurological component;
- a psychosocial assessment; and
- an appropriate diagnostic work-up to determine the type and cause of the pain.²⁷

2. Assess for pressure ulcer related pain in adults using a scale that is valid and reliable. (Strength of Evidence = C; Strength of Recommendation = 👍)

The McGill Pain Questionnaire (MPQ) and FACES were used in a study of 47 people with Category/Stage II to IV pressure ulcers, and a statistically significant relationship (Pearson's $r = 0.90$) was found between current pain intensity and FACES²⁰ (Level 5 study). Dallam et al. (1995)¹ found that the VAS correlated with FACES ($r = 0.92$) and the Category/Stage of the pressure ulcer ($r = 0.37$). Pressure ulcer pain intensity correlated with generalized pain ($r = 0.59$) (Level 3 study). Variability in VAS scores significantly increased as FACES values increased¹⁰ (Level 5 study). In addition, the VAS and FACES proved to be highly reliable for pain assessment in individuals with decreased verbal and abstract thinking.¹⁰

2.1. Incorporate the individual's cognitive ability into the selection of a pain assessment tool. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Pain assessment tools should be appropriate to the individual's cognitive level. Individuals with pressure ulcers are often older and may have cognitive impairment. Studies investigating the use of FACES by cognitively impaired adults report that this population has difficulty using this scale compared with other self-report pain assessment tools.²⁸⁻³³ Likewise, the VAS has been shown to have limited reliability when used by cognitively impaired adults with pain associated with a range of conditions^{28, 29, 34} (indirect evidence). Current evidence suggests that the MPQ, which is validated in populations with pressure ulcer pain,²⁰ provides the most reliable pain assessment for cognitively impaired individuals.^{35, 36}

Some researchers have reported the ability of mildly to moderately cognitively impaired older adults to respond to a simple direct yes/no question, such as:³⁷⁻⁴⁰

- Do you have pain?
- Where is your pain?
- Can you point to or touch the area of pain?
- Do you have wound pain every day?
- Does wound pain keep you from sleeping
- Does wound pain keep you from doing activities you enjoy?

3. Assess for pain in neonates and children using a validated scale. (Strength of Evidence = C; Strength of Recommendation = 👍)

Children and neonates can experience pressure ulcer related pain,^{1, 10, 41-45} and assessment for pain is mandated in the US.²⁶

3.1. Use the FLACC (Face, Leg, Activity, Cry, and Consolability) tool for children 2 months to 7 years of age. (Strength of Evidence = C; Strength of Recommendation = 👉)

The FLACC tool was found to be valid and have high interrater reliability in a study of 89 children aged from two months to seven years who experienced postoperative pain⁴⁴ (indirect evidence).

3.2. Use the CRIES (Crying; Requires O2 for Saturation > 95%; Increasing vital signs; Expression; Sleepless) Scale for neonates up to 6 months. (Strength of Evidence = C; Strength of Recommendation = 👍)

For neonates up to six months of age, the CRIES scale is effective.^{42, 43} The VAS can be used in older children.

- 4. Pain assessment tools may not provide sufficient information to guide interventions. Investigate other aspects of the pain in order to provide more effective, individualized interventions. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

- 4.1. Incorporate the individual's body language and nonverbal cues into the assessment of pain. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

For cognitively impaired individuals and those who are nonverbal (including infants), observe for specific behaviors (e.g., change in activity, loss of appetite, guarding, grimacing, withdrawal, crying out and moaning) during wound procedures and movement. The AGS Panel on Pharmacological Management of Persistent Pain in Older Adults (2009)⁴⁶ recommends looking for behaviors such as facial expressions, verbalizations or vocalizations, body movements, changes in interpersonal interactions, and changes in activity patterns or routines.

- 4.2. Incorporate the words used by the individual to express pressure ulcer pain character into the assessment of pain. (Strength of Evidence = C; Strength of Recommendation = 👍)**

The MPQ includes a broad range of words to describe pain character. Acute pain is associated with pain terms such as quick, sharp and short. Chronic pain is associated with reports of constant or persistent pain.^{1, 20} Neuropathic pain is associated with terms such as 'pins and needles', stabbing, shooting, 'hot poker' and electric pulse.²⁰ Health professionals should have high index of suspicion for neuropathy when these terms are reported.

- 4.3. Evaluate factors that increase pain frequency and/or intensity when conducting an assessment of pain. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

In conducting a pain assessment, consider activities that influence pain (e.g., wound dressing changes, sharp debridement, movement and touch). Gunes (2008)²⁰ found that individuals with pressure ulcer pain reported increased pain intensity at dressing changes compared with at rest.

- 4.4. Evaluate the duration of the pressure ulcer and associated pain when conducting an assessment of pain. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Gunes (2008)²⁰ used both the MPQ and FACES to assess pressure ulcer pain. For the majority of individuals with pressure ulcers (94.6%, 44 out of 47), pain was constantly present. Pain intensity and constancy was associated with increasing Category/Stage of the pressure ulcer. About half (52%) of participants with Category/Stage II pressure ulcers reported intermittent pain and the majority of individuals with Category/Stage III pressure ulcers (56%) and Category/Stage IV pressure ulcers (67%) pressure ulcers reported constant pain. Pain scores on the MPQ increased as ulcer duration increased. Pain intensity was significantly greater for pressure ulcers of longer duration ($p < 0.05$) (Level 3 study).

- 5. Assess for deterioration of the ulcer or possible infection when the individual reports increasing intensity of pain over time. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Increasing presence or intensity in pain is an indication that a chronic wound may be infected and a comprehensive assessment of the pressure ulcer should be performed.⁴⁷⁻⁴⁹ See the *Assessment and Treatment of Infection and Biofilms* section of the guideline for recommendations on assessment and management of infection.

- 6. Assess the impact of pressure ulcer pain on the individual's quality of life. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Pressure ulcers have measureable and persistent impact on health-related quality of life measures. In one study, participants with pressure ulcers were found to have significantly lower overall scores on Short Form Health Survey (SF-36) and EQ-5D™ ($p < 0.001$) than participants without pressure ulcers. Pressure ulcers were found to impact especially on measures of physical functioning ($p = 0.001$). Perceived pain was of borderline significance ($p = 0.06$)⁵⁰ (Level 5 study).

Prevent Pressure Ulcer Pain

1. **Use a lift or transfer sheet to minimize friction and/or shear when repositioning an individual, keeping bed linens smooth and unwrinkled. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Repositioning is associated with pain in individuals with both medical and surgical conditions. One observational study ($n = 1,395$) found individuals experienced a mean score of 4.9 ± 3.1 on a 0 to 10 numerical rating scale when being turned, even when interventions to reduce pain were implemented⁵¹ (indirect evidence).

Hyperalgesia is described by individuals as occurring during repositioning and transfer activities² and should be addressed prior to commencing movement. Using a lift or transfer sheet can minimize shear when repositioning an individual in bed. Keeping bed linens smooth and unwrinkled can promote comfort and decrease pressure. Provide positional support to affected pressure ulcer area where possible. Move gently and listen to the individual to guide movements.

2. **Position the individual off the pressure ulcer whenever possible. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Pressure ulcers are caused, at least in part, by unrelieved pressure and the resulting ischemia of tissues that occurs between an external surface and underlying bone. Continued positioning on a pressure ulcer can result in increased pressure, pain and damage to the area. Keeping the individual off the pressure ulcer will relieve pain and ischemia, enhance soft tissue viability and promote healing of the pressure ulcer.^{52, 53}

3. **Avoid postures that increase pressure, such as Fowler's position greater than 30° or 90° side-lying position, or the semi-recumbent position. (Strength of Evidence = C; Strength of Recommendation = 👍)**

The *Repositioning and Early Mobilization* section of the guideline provides detailed recommendations on the role of positioning to both prevent and treat pressure ulcers.

Manage Pressure Ulcer Pain

1. **Organize care delivery to ensure that it is coordinated with pain medication administration and that minimal interruptions follow. Set priorities for treatment. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Pain management includes performing care after administration of pain medication to minimize pain experienced and interruptions to comfort for the individual.

2. **Encourage individuals to request a 'time out' during any procedure that causes pain. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Anxiety is influenced by both physiological and psychological factors. Anxiety can be ameliorated, at least to some degree, by:

- talking with individuals about their wound-related pain;
- providing a detailed explanation of each procedure;
- answering their questions;
- allowing active participation;

- pacing the procedure to the individual's preferences; and
- allowing time outs as needed.⁵⁴⁻⁵⁶

3. Reduce pressure ulcer pain by keeping the wound bed covered and moist, and using a non-adherent dressing. (Note: Stable dry eschar is usually not moistened). (Strength of Evidence = B; Strength of Recommendation = 👍👍)

Wounds resurface more quickly in the presence of moist wound healing.⁵⁷ Pressure ulcer pain can be minimized by keeping the pressure ulcer wound bed moist and covered.⁵⁸

4. Select a wound dressing that requires less frequent changing and is less likely to cause pain. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Hydrocolloids, hydrogels, alginates, polymeric membrane foams, foam and soft silicone wound dressings should be considered for management of painful pressure ulcers. A wound dressing that allows for less frequent changing is advised. Nonadherent and/or moist dressings cause less pain and trauma on removal.⁵⁹⁻⁶⁸ Gauze dressings are more likely to cause pain.

See the *Wound Dressings for Treatment of Pressure Ulcers* section of the guideline for further recommendations on wound dressing selection.

4.1. Where available, consider ibuprofen impregnated wound dressings as a topical analgesic treatment for pressure ulcer pain. (Strength of Evidence = C; Strength of Recommendation = 👉)

n.b. Ibuprofen-impregnated dressings are not available in the U.S.

Although ibuprofen impregnated dressings have not been tested in pressure ulcers, a recent Cochrane review⁶⁹ provides indirect evidence on the effectiveness of ibuprofen impregnated dressings. The review included two randomized controlled trials conducted on participants with wound of mixed etiology. In one of the studies⁷⁰ ibuprofen impregnated dressing was associated with a 40% reduction in pain from baseline, and a 30% reduction in pain compared with a foam dressing. In the second study,⁷¹ 19% more participants experienced at least a 50% reduction in their pain levels compared with foam dressing (indirect evidence).

5. Consider the use of non-pharmacological pain management strategies to reduce pain associated with pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based on expert opinion. A large range of non-pharmacological pain management strategies are used in managing pain including:

- music,
- progressive relaxation,
- position changes,
- meditation and self-hypnosis,
- guided imagery,
- healing touch,
- distraction and conversation,
- warmth applications, and
- electrotherapy therapy (e.g., transcutaneous electrical nerve stimulation [TENS]).

While few studies have been conducted on the effectiveness of these non-pharmacological strategies for managing pressure ulcer pain, their benefit in treating chronic neuropathic pain has been reported.^{22, 55, 72, 73}

6. Administer pain medication regularly, in the appropriate dose, to control chronic pain following the World Health Organization Pain Dosing Ladder. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

The World Health Organization (WHO) Pain Dosing Ladder⁷⁴ is a validated and effective method for relieving pain related to cancer and in other individuals with pain.²⁷ Step one is the accurate assessment and measurement of the individual's pain on a validated pain intensity scale, and then matching the pain intensity to the potency of the analgesic, beginning with nonopioid medication and proceeding to an opioid with an adjuvant. On a 10-point scale, mild pain would be 1 to 3, moderate pain 4 to 6, and severe pain 7 to 10. Mild pain would be treated with a nonopioid, moderate pain with a mild opioid with or without a nonopioid or adjuvant, and severe pain with a strong opioid with or without an adjuvant. The WHO Pain Dosing Ladder⁷⁴ is based on the goals of minimizing side effects and maximizing pain relief. Opioids act on the central nervous system by altering the pain perception, while nonopioids act on peripheral nerves to block painful impulses. Adjuvants enhance the effectiveness of analgesics synergistically.²⁷ Pain medication needs to be administered regularly in the appropriate dose to control chronic pain. Individuals with chronic wounds, especially older adults and those with dementia, continue to be under-assessed and under-treated.^{18, 75, 76}

To maintain analgesic effects, administer drugs 'by the clock' every three to six hours by the least invasive route.⁷⁷

A study (n = 34) investigating an innovative pressure ulcer pain management strategy found that a nitrous oxide/oxygen mixture administered five minutes prior to, and throughout wound care significantly reduced (p < 0.001) pain assessed on validated pain tools compared to morphine (1 mg/ 10 kg body weight) administered 30 minutes prior to wound care⁷⁸ (Level 2 study). No significant difference was found with regard to safety or tolerability. Further research on such pain management strategies is warranted.

7. Encourage repositioning as a means to reduce pain, if consistent with the individual's wishes. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Individuals who are in pain do not wish to move, yet repositioning remains a high priority for helping to decrease pain.⁷⁶ Even small changes in position are helpful in decreasing pressure. Providing adequate analgesia 20 to 60 minutes prior to planned movement may be helpful in maintaining repositioning programs.

Reduce Procedural Pain

1. Use adequate pain control measures, including additional dosing, prior to commencing wound care procedures. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Wound care procedures including wound manipulation, wound cleansing, debridement and dressing changes are painful. Topical medications are more effective when applied 20 to 30 minutes, and up to 60 minutes, prior to wound treatments.⁷⁹

2. Consider using topical opioids (diamorphine or benzydamine 3%) to reduce or eliminate pressure ulcer pain. (Strength of Evidence = B; Strength of Recommendation = 👉)

Caution: Topically applied opioids may be associated with increased systemic side effects in individuals taking systemic opioids. Local itching and irritation has been reported, but not more frequently than when a placebo gel is applied.⁸⁰

Opioid receptors have been found on peripheral nerves and inflamed tissue, suggesting that topically applied opioids may provide relief of pressure ulcer pain.⁸¹ Availability of these preparations may vary from country to country.

Flock (2003)⁷ conducted a randomized, blinded, placebo-controlled crossover pilot trial of seven hospice patients with painful Category/Stage II or III pressure ulcers to compare pre and post treatment pain using IntraSite® and diamorphine gels. Pain scores improved significantly more at one hour (p = 0.003) and 12 hours (p = 0.005) after diamorphine gel application compared with placebo and baseline (Level 2 study). A retrospective study of 15 older individuals with Category/Stage II pressure ulcers was done

to assess the effectiveness of diamorphine-IntraSite® gel in relieving pain. Participants showed an improvement on the VAS of a mean of 4 points (9.4 to 4.6, $p < 0.02$)³ (Level 3 study).

Twillman et al. (1999)⁸² treated nine consecutive participants with a variety of painful skin ulcers with a topical morphine-infused gel dressing. Seven of the nine participants reported substantial relief, another participants reported a lesser (but still significant) degree of analgesia, and the ninth reported no relief for a non-open ulcer (Level 5 study).

- 3. Consider using topical anesthetics to reduce or eliminate pressure ulcer pain. (Strength of Evidence = C; Strength of Recommendation = ↪)**

This statement is based on expert opinion. Topical anesthetics include eutectic mixture of lidocaine and prilocaine (EMLA®, AstraZeneca, Alderley Park, UK), which is applied to the periwound area.

Manage Chronic Pain

- 1. Refer the individual with chronic pain related to pressure ulceration to the appropriate pain and/or wound clinic resources. (Strength of Evidence = C; Strength of Recommendation = 👍)**
- 2. Work with the multi-disciplinary health care team to develop a holistic plan to manage chronic pressure ulcer pain. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These statements are based on expert opinion. Chronic wound pain or persistent, continuous neuropathic pain that is resistant to simple analgesia requires the development of a chronic pain management plan that may incorporate short and long term pharmacological and non-pharmacological interventions. This should be developed with input from a range of health professionals (e.g., pain specialists, medical professionals, nursing and allied health professionals), the individual and his or her caregivers.

Individualized strategies may include:

- local anesthetics;^{5, 83}
- adjuvant medication (e.g., tricyclic antidepressants or antiepileptic);^{5, 83} and
- non-pharmacological interventions outlined elsewhere in this section.^{22, 55, 72}

Educate Individuals, Family and Health Care Providers

- 1. Educate the individual, caregivers, and health care providers about causes, assessment and management of pressure ulcer pain. (Strength of Evidence = C; Strength of Recommendation = 👍)**

The individual and his or her significant other(s) are integral to adequate management of pressure ulcer pain.⁸⁴ Educating the individual and family about the cause and expected duration of pain as well as what to do to minimize it can enhance understanding and compliance, and subsequently reduce pain.^{4, 8, 11, 15-19, 52, 84-87}

Health professionals may not address pressure ulcer associated pain as a priority; however, the presence of a painful pressure ulcer is restrictive to the individual's health related quality of life and, therefore, their convalescence.⁵⁰ It is observed that within the interprofessional team, communication regarding the pressure ulcer and associated pain may be lacking.⁸⁸ Balancing concurrent goals of healing the pressure ulcer and enabling participation in usual roles and activities should be considered a priority. Health professionals in the home care setting should assess for pressure ulcer pain on a regular basis and update care plans as the individual's pain changes.⁸⁸

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WOUND BED PREPARATION

This section is a background to the discussion, evidence and recommendations presented in the next four guideline sections on cleansing; debridement; infection and biofilms; and wound dressings.

Wound bed preparation is a clinical concept encompassing a systematic and holistic approach to wound evaluation and treatment that promotes a wound environment that will allow normal progression toward wound healing. The overall goal of wound bed preparation is to promote a well-vascularized wound bed, free from non-viable tissue and excess exudate, and with a reduced bacterial burden and reduced edema, that is optimal for development of healthy granulation tissue.^{1, 2}

Wound bed preparation incorporates four major aspects of wound care, represented by the acronym TIME:¹⁻⁴

- Tissue management,
- Infection and inflammation control,
- Moisture balance, and
- Epithelial edge advancement.

Evaluating and optimizing each of these four components of wound care removes the barriers that are known to delay normal healing in chronic wounds.

Removing devitalized or necrotic tissue and its associated bacterial and cellular burden provides a stimulatory wound environment that promotes healthy tissue growth.^{2, 4} The guideline sections *Wound Care: Cleansing* and *Wound Care: Debridement* provides comprehensive discussion and recommendations on cleansing techniques, appropriate use of debridement, selection of debridement techniques, and cautions to consider.

Treatment of bacterial burden is a significant consideration in chronic wounds that are often heavily colonized. The role of biofilm in delaying healing is also a concern. Treatment of infection reduces bacterial counts, inflammatory cytokines and protease activity; and increases growth factor activity in the wound bed, promoting health healing.^{2, 4} The guideline section *Assessment and Treatment of Infection and Biofilms* provides further discussions and recommendations for clinical practice.

Promoting a warm, moist wound bed prevents desiccation, stimulates growth factor activity and promotes accelerated re-epithelialization, but does not increase infection. Control of excessive moisture prevents maceration of surrounding tissue.^{1, 3} Appropriate selection of moisture-retentive dressings and use of absorptive dressings in heavily exudating wounds plays a key role in promoting moisture balance to promote healing.¹ The guideline section *Wound Dressings* provides recommendations to guide practice.

Failure of the epithelium to advance indicates that barriers to healing have not been adequately removed and further preparation of wound bed is needed. A non-advancing wound edge, or undermining, can be due to abnormalities in the cellular matrix, hypoxia of the wound bed or abnormal protease activity.³ Control of infection and inflammation; removal of cellular burden through debridement; and control of wound moisture are all important considerations in promoting epithelial advancement.¹ Sequential monitoring of the advance of epithelium at the wound edge allows health professionals to assess the adequacy of wound bed preparation.

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WOUND CARE: CLEANSING

Introduction

Wound cleansing is the process of using fluids to remove surface contaminants (debris), remnants of previous dressings and bacteria from the wound and peri-wound surface.¹ Cleansing does not ‘sterilize’ a wound; it is ‘washing out’ a wound. If fibrinous material and detritus/debris cannot be removed gently with fluids, then debridement (i.e. removal of devitalized tissue) may be required (See *Wound Care: Debridement* section of the guideline).

Research on cleansing of pressure ulcers is sparse. There are no studies that could be found comparing cleansing versus not cleansing pressure ulcers. Most clinical articles regarding cleansing speak to general cleansing principles for any type of wound bed preparation. Cleansing is an important first step in preparing the pressure ulcer wound bed to heal by removing surface debris and dressing remnants and allowing better wound visualization for assessment.

Cleansing must be extremely gentle in re-epithelializing pressure ulcers to prevent disruption of the neoepithelium. However, pressure ulcers with devitalized tissue or suspected biofilm usually require more aggressive use of irrigating solutions or debridement.

Comprehensive systematic reviews^{2,3} have identified no direct evidence to support the use of any specific wound cleansing solutions or wound cleansing techniques for pressure ulcers.

Recommendations

1. **Cleanse the pressure ulcer at the time of each dressing change. (Strength of Evidence = C; Strength of Recommendation = 👍)**
 - 1.1. **Cleanse most pressure ulcers with potable water (i.e., water suitable for drinking) or normal saline. (Strength of Evidence = C; Strength of Recommendation = 👍)**
 - 1.2. **Consider using an aseptic technique when the individual, the wound or the wound healing environment is compromised. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Aseptic technique using sterile products should be considered when the individual is immunocompromised; or if the wound enters a sterile body cavity or when the wound healing environment is compromised; otherwise, clean wound management technique is appropriate⁴ (indirect evidence).

For clean pressure ulcers (those with no debris or confirmed bacterial infection), potable (drinkable) tap water or normal saline is recommended. Boiled and cooled water is an effective wound cleansing solution if potable water or normal saline is not available (indirect evidence).⁵⁻⁷ No differences in rates of infection and healing between potable water and normal saline have been noted in the cleansing of chronic wounds in adults or children (indirect evidence).^{1, 6, 8, 9}

- 1.3. **Consider using cleansing solutions with surfactants and/or antimicrobials to clean pressure ulcers with debris, confirmed infection, suspected infection, or suspected high levels of bacterial colonization. (Strength of Evidence = C; Strength of Recommendation = 👍)**

See the *Assessment and Treatment of Infection and Biofilms* section of the guideline for information on appropriate selection of topical antiseptics and cytotoxic profiles of different topical preparations.

For dirty pressure ulcers (those with debris and/or high bacterial colonization), a cleansing solution with a surfactant and/or antimicrobial agent (antibiotic, antiseptic) appropriate for the wound and consistent with current toxicity/efficacy recommendations should be considered until

the wound bed is clean.¹ For pressure ulcers with suspected biofilm, debridement is the most effective management strategy (indirect evidence and consensus opinion).^{10, 11}

Avoid cleansing agents that are cytotoxic to fibroblasts or use them for only a short period of time to reduce bioburden. Cleansers that are formulated to remove fecal material (skin cleansers) are cytotoxic, and should not be used in wounds.¹ When an antiseptic is added to a wound cleanser its toxicity increases, and the benefit of adding an antiseptic to wound cleanser has not been documented.¹ Avoid products intended for use only on intact skin. Solutions that are at room temperature when applied to the wound are reported to be less painful.

1.4. Cleanse pressure ulcers with sinus tracts/tunneling/undermining with caution. (Strength of Evidence = C; Strength of Recommendation = 👉)

When the wound bed cannot be visualized due to sinus tracts/tunneling/undermining there is a possibility that the cleansing solution may not be retrieved.

2. Apply cleansing solution with sufficient pressure to cleanse the wound without damaging tissue or driving bacteria into the wound. (Strength of Evidence = C; Strength of Recommendation = 👉)

Pressure ulcer cleansing can be accomplished by irrigating the ulcer with fluid. In order to remove the debris in the ulcer, the force of the irrigation stream has to be greater than the adhesion forces holding the debris to the wound surface. Generally, irrigation pressure between four and 15 pounds per square inch (psi) should be adequate to clean the surface of the pressure ulcer without causing trauma to the wound bed.^{1,7} One way to produce pressurized irrigation is to deliver the irrigant from a syringe through a needle or catheter. For example, with a 19-gauge needle, the pressure generated with a 35ml syringe is 8 psi.¹ There are also many commercially available irrigation devices.

2.1. Contain and properly dispose of used irrigation solution to reduce cross-contamination. (Strength of Evidence = C; Strength of Recommendation = 👉👉)

Environmental contamination is possible with these devices, and infection-control precautions should be routinely used.¹²

3. Cleanse surrounding skin. (Strength of Evidence = B; Strength of Recommendation = 👉👉)

Periwound cleansing with normal saline caused a statistically significant decrease in wound and periwound microbial counts of pressure ulcers (17 ulcers at different locations) leading the authors to suggest that daily periwound cleansing was beneficial and should be a part of standard pressure ulcer wound care¹³ (Level 4 study). In a second study, Konya et al. (2005)¹⁴ compared cleansing of the periwound skin with normal saline (n = 84) to cleansing with a pH-balanced skin cleanser (n = 90). For pressure ulcers of all Category/Stage, healing time was shorter when cleansed with a pH-balanced skin cleanser and water; however the decreased healing time was only statistically significant for Category/Stage II pressure ulcers (median healing 15 days versus 20 days, p=0.002). Lack of control for the increased potential for excreta in ulcers of the sacrum, ischial tuberosities and coccyx may have influenced the findings (Level 3 study).

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WOUND CARE: DEBRIDEMENT

Introduction

Despite comprehensive literature reviews, very little direct evidence (i.e., studies of debridement of pressure ulcers in humans) was identified to support these recommendations. As many as ten clinical practice guidelines support the expert opinion statements in this section. Limited direct evidence and indirect evidence (i.e., studies of debridement in other types of wounds) are included.

There is strong informed clinical consensus to support the role of debridement in wound bed preparation, despite the ethically understandable lack of randomized controlled trials directly comparing debridement to no debridement in human subjects.¹⁻¹⁷ In fact, prior to Steed's pivotal post hoc analysis of a non-randomized comparison of debridement rates in wound healing centers participating in a recombinant growth factor study, there was no experimental clinical data to support the commonly accepted view and clinical practice that debridement was beneficial to wound healing.^{7,8} Steed's finding that aggressive debridement of diabetic foot ulcers was associated with increased wound closure set the stage for investigation into the cascade of benefits afforded by initial and maintenance debridement.^{7,8}

Debridement in the presence of adequate wound bed vascularity is believed to hold a key role in wound bed preparation, addressing not only the barriers to chronic wound healing but also providing potential stimulatory effects.^{4,5,18}

Recommendations

- 1. Debride devitalized tissue within the wound bed or edge of pressure ulcers when appropriate to the individual's condition and consistent with overall goals of care. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Caution: Debridement should only be performed when there is adequate perfusion to the wound (refer to Recommendation 9).

Devitalized tissue is tissue that is nonviable or necrotic. It is normally moist, yellow, green, tan, or gray and may become thick and leathery with dry black or brown eschar. Debridement of devitalized tissue is an essential component of wound bed preparation.^{4,5,7,18,19}

Necrotic tissue is a nidus for infection, prolonging the inflammatory response, mechanically obstructing contraction, and impeding re-epithelialization.²⁰ It may mask underlying fluid collections or abscesses and limit full assessment capability in determining ulcer depth.²⁰ If appropriate to the individual's condition and consistent with overall goals of care, a thorough initial debridement of the pressure ulcer^{1,2,11,12,15-17,21} and the hyperproliferative epithelial edge should be performed to elicit an acute wound-healing response. Maintenance debridement should follow as dictated by the ulcer bed condition.^{4,5,19}

In cases where individuals are receiving palliative care, their overall quality of life should be taken into consideration when deciding whether to debride and the manner in which it should be accomplished.^{14,15}

- 2. Debride the wound bed when the presence of biofilm is suspected or confirmed. (Strength of Evidence = C; Strength of Recommendation = 👍)**

When a wound has delayed healing (i.e., four weeks or more) and fails to respond to standard wound care and/or antimicrobial therapy, have a high index of suspicion of the presence of biofilm. See the *Assessment and Treatment of Infection and Biofilms* section for more information.

Wolcott et al. (2010)²² demonstrated in *invitro* models and a small scale clinical study that less mature biofilm is more susceptible to topical antimicrobial treatment. *Invitro* models demonstrated that biofilm develops tolerance to antimicrobial treatment within 24 to 96 hours and suggests that removal of active

cells from the surface of biofilm exposes dormant bacteria that have increased susceptibility to treatment. Biofilm samples from venous leg ulcers subjected to conservative sharp debridement showed peak susceptibility to antibiotic therapy between 24 hours and 48 hours post-debridement. By 72 hours, susceptibility had returned to that of mature biofilm samples (indirect evidence).

3. Select the debridement method(s) most appropriate to the individual, the wound bed, and the clinical setting. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

The most common methods used for debriding pressure ulcers are:

- surgical/sharp,
- conservative sharp,
- autolytic,
- enzymatic,
- larval, and
- mechanical (including ultrasound and hydrosurgical).

Surgical/sharp debridement is rapid wound debridement in which devitalized tissue is removed from the wound using scalpel and scissors under general or local topical anesthetic. Surgical debridement extends into viable tissue, and the resultant bleeding stimulates the production of bloodborne endogenous growth factors acting as chemo attractants for inflammatory cells and mitogens for both fibroblasts and epithelial cells.^{10, 19} It is usually confined to specialist inpatient clinics that have the capacity for anesthesia and the ability to maintain strict asepsis and control bleeding, and is performed by a surgeon, other qualified medical doctor, podiatrist, or advanced practitioner.

Surgical debridement is most appropriate when there is an urgent need to remove extensive, devitalized tissue. A pressure ulcer should be surgically debrided when there is a clinical need for extensive debridement; the degree of undermining and sinus tract/tunneling cannot be determined; there is advancing cellulitis; bone and infected hardware must be removed; and/or the individual is septic secondary to the pressure ulcer.²³

The hydrosurgical water knife is an alternative tool to achieve surgical-type debridement. It can be regulated to precisely control the depth of debridement through pressure-setting calibration.²⁴ A non-randomized study comparing hydrosurgery to hydrogel therapy reported no difference in healing rates, but the time to achieve complete debridement was 1.3 ± 0.6 days for hydrosurgery, compared to 4.3 ± 3.9 days for hydrogel in chronic venous leg ulcers²⁵ (indirect evidence). Additionally, a retrospective study using historical controls of acute and chronic wounds having received hydrosurgery compared to conventional sharp debridement reported fewer surgical procedures being required in the hydrosurgery group²⁶ (indirect evidence).

Conservative sharp debridement employs the use of scalpels, curettes, scissors, forceps, and rongeurs to remove devitalized tissue without pain or bleeding.²⁷ This method of debridement decreases wound surface bacterial burden and removes senescent cells, converting a chronic wound into an acute wound.¹⁹

Surgical/sharp and conservative sharp debridement should only be performed in anatomical locations possessing adequate vascularity to support the ability to heal.¹⁰ Knowledge of anatomy and training is vital for a person using sharp debridement techniques. Caution must be exercised with immunocompromised individuals to avoid large open cavities that may serve as portals for opportunistic infection.¹⁹ Additionally, caution must be exerted in those individuals with bleeding disorders and those taking anticoagulants.^{11, 19, 28} Access to conservative sharp debridement may be limited in certain care settings.

Saap et al. (2002)⁷ developed and tested a Debridement Performance Index (DPI) scoring system. The DPI addresses three parameters: removal of callus; removal of an ulcer's edge; undermining; and removal of wound bed necrotic or infected tissue.⁷ Each parameter is then scored (0 = debridement needed, not performed; 1 = debridement needed and performed; 2 = debridement not needed and not performed). Using digital images from diabetic foot ulcers previously enrolled in a controlled,

randomized bioengineered skin construct clinical trial where the observer was blinded to treatment, Saap et al. (2002)⁷ reported that the lower the DPI, the lower the incidence of wound closure. Although the DPI scoring system for debridement performance appears to be a promising predictive tool for determining clinical diabetic foot healing outcomes, a lack of follow up refinement and testing of the tool has precluded its adoption into clinical practice to date (indirect evidence).

Golinko et al. (2009)²⁹ concur that surgical debridement should be performed until all devitalized tissue is excised. Their retrospective study conducted on pressure ulcers suggested that histopathological analysis of tissue excised during surgical debridement can be used to determine the adequacy of the debridement as visual inspection of tissue alone is inadequate. Study results demonstrated that using visual assessment alone, hyperkeratotic and fibrotic tissue and osteomyelitis remained even following surgical debridement undertaken by experienced surgeons (Level 5 study).

Williams et al. (2005)⁹ in a non-randomized pilot study of individuals with chronic venous leg ulcers, reported that individuals receiving sharp circulator curette debridement exhibited significant healing at four weeks post-debridement when compared to those who did not receive conservative sharp debridement as measured by a decrease in ulcer mean surface area. But there were no differences in infection rates between the two groups or a significant difference in mean surface area at 20 weeks. It is important to acknowledge that given the use of a less rigorous design, the groups are less homogenous, which may explain some of the variability. Those in the control group received no sharp debridement, and at baseline had no slough or devitalized tissue. They presented with 15 to 20% granulation, while those receiving debridement at baseline had slough and no granulation.

Autolysis is a highly selective form of slow debridement occurring naturally in all wound types.¹⁹ Macrophages phagocytize bacteria, and endogenous proteolytic enzymes such as collagenase, elastase, myeloperoxidase, acid hydrolase, and lysozymes selectively liquefy and separate devitalized tissue and eschar from healthy tissue.¹⁹ The aim is to regulate the wound environment to achieve optimal moisture, pH and humidity in order that autolysis will occur (indirect clinical evidence).

Moisture-retentive dressings such as hydrocolloids, transparent films, and hydrogels rehydrate dry devitalized tissue and provide a moist environment for the body's own proteolytic enzymes and phagocytic cells to debride necrotic tissue.²⁰ In heavily exuding wounds, absorption dressings (e.g., calcium alginate, cellulose fiber) are more appropriate.

In two small, randomized controlled trials (RCTs) comparing amorphous hydrogels, no difference was noted in rates of debridement or healing^{30, 31} (Level 2 studies). This suggests that no specific type of amorphous hydrogel is superior to another for achieving autolysis.

In two RCTs comparing autolytic debridement using hydrocolloids to enzymatic debridement using a topical enzyme (collagenase) varying results were reported. Among individuals with Category/Stage III pressure ulcers, Burgos (2000)³² reported no difference in healing between collagenase and hydrocolloid use (Level 2 study), while Muller et al. (2001)³³ found collagenase to be faster in achieving debridement of soft necrotic tissue and wound healing after removing the hard eschar in Category/Stage IV calcaneal pressure ulcers (Level 2 study). It is important to note that in Muller's study, surgical debridement was performed prior to subject randomization. Among individuals with Category/Stage III pressure ulcers, Burgos (2000)³² reported that those treated with collagenase exhibited a positive trend toward healing (83.3% healed) compared to (73.7%) in those treated with hydrocolloid, but this difference did not reach significance.

Autolytic debridement is contraindicated in the presence of untreated infection or extensive necrotic tissue, in large ulcers with undermining and sinus tracts, and in individuals with compromised immunity.^{2, 11, 12, 14-16, 21}

Enzymatic debridement is accomplished by the application of exogenous proteolytic or fibrinolytic enzymes to the ulcer surface that will work synergistically with the body's own endogenous enzymes.²⁰ The availability of enzymatic debriding agents may vary by country, and their properties and benefits in debridement vary. Fibrinolysin/deoxyribonuclease (DNase) breaks down fibrin components of blood

clots, inactivates fibrinogen and other clotting factors, and dilates the blood vessels, allowing macrophages to debride the devitalized tissue.¹⁹ Bacterial collagenase degrades native collagen with great specificity, yet is not active against keratin, fat, or fibrin.¹⁹ Papain, a proteolytic enzyme, is inactive against collagen and digests devitalized tissue through the liquefaction of fibrinous debris. Papain requires an activator to function; urea serving as an activator assists in denaturing nonviable protein, making it amenable to proteolysis.¹⁹ Heavy metals may inactivate some enzymes. Follow manufacturer's directions when using enzymatic debriding agents.

In a RCT (n = 28) comparing papain-urea to collagenase for debriding Category/Stage II to IV pressure ulcers, there was a significantly greater reduction in devitalized tissue (p < 0.0167) and significantly greater amount of granulation (p < 0.0167) for those receiving papain-urea, but the ulcer healing rates were not different (p > 0.05) between groups³⁴ (Level 2 study). In a double-blind RCT (n = 135 included, n = 78 results analyzed) comparing collagenase to fibrinolysin/deoxyribonuclease for debriding Category/Stage II to IV pressure ulcers no significant difference (p = 0.164) was found between the two groups for the reduction of devitalized tissue³⁵ (Level 2 study). A small RCT (n = 27) demonstrated superior debridement of wounds with collagenase and a semi-occlusive dressing compared with a hydrogel dressing for Category/Stage III and IV pressure ulcers in individuals in a long term care setting. Approximately 85% of the pressure ulcers managed with collagenase achieved complete debridement at 42 days compared with 29% of those treated with hydrogel wound dressing (p < 0.03). The pressure ulcers debrided with collagenase were also statistically more likely to have achieved complete wound closure within 84 days (69% versus 21%, p = 0.02)³⁶ (Level 2 study).

Mechanical debridement is often a non-selective form of debridement that can result in the removal of both devitalized as well as viable tissue.²⁰ Examples of mechanical debriding agents include:

- wet-to-dry dressings,
- monofilament fiber pads,
- wound irrigation,
- low frequency ultrasound, and
- ultrasonic mist.

Wet-to-dry gauze dressings can be painful, and may remove healthy tissue. Wet-to-dry gauze dressings are being used less frequently. Research suggests they are associated with slower wound healing and are costly in professional time due to the need for frequent wound dressing changes.^{37, 38} A monofilament fiber pad removes slough and devitalized tissue, and potentially disrupts biofilm within the wound bed; however, more research is required on its effectiveness in promoting wound healing.³⁹

Noncontact low frequency ultrasound (ultrasonic mist) debridement is increasingly being used to remove devitalized tissue. This selective method uses low frequency ultrasound electrical currents converted to mechanical vibrations that stimulate a probe that in turn amplifies the vibrations, converting them into acoustic energy that is transferred to the wound tissue. Ultrasound debridement provides both mechanical and hydrodynamic effects directly in the wound bed due to cavitation.¹⁸ The application of ultrasound causes creation and destruction of small bubbles in fluid that expand and rapidly collapse ('imploding gaps') resulting in turbulent shockwaves and currents that lead to erosion of necrotic tissue and fibrin. Further information on irrigation, whirlpool, and (noncontact low frequency ultrasound) is the guideline sections *Wound Care: Cleansing* and *Biophysical Agents in Pressure Ulcer Treatment*.

Biological debridement (larval therapy) consists of application of sterile fly larvae to the devitalized ulcer bed. Sterile maggots produce a mixture of proteolytic enzymes including collagenase, allantoin, and other agents with broad-spectrum antibacterial activity.^{19, 20} Biological therapy should not be used where there are exposed blood vessels; acute infections that are limb- or life-threatening; ulcers requiring frequent inspections; necrotic bone or tendon tissues; or circulatory impairment significant enough to impair ability to heal.^{20, 40}

In a clinical series of individuals with pressure ulcers treated with larval therapy compared with conventional debridement, faster debridement and granulation tissue formation was reported in those treated with maggots⁴¹ (Level 2 study).

4. **Use mechanical, autolytic, enzymatic, and/or biological methods of debridement when there is no urgent clinical need for drainage or removal of devitalized tissue. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is supported by expert opinion from nine clinical practice guidelines.^{1, 2, 11-15, 17, 21}

5. **Surgical/sharp debridement is recommended in the presence of extensive necrosis, advancing cellulitis, crepitus, fluctuance, and/or sepsis secondary to ulcer-related infection. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is supported by expert opinion from ten clinical practice guidelines.^{1, 2, 11-17, 21}

6. **Conservative sharp debridement and surgical/sharp debridement must be performed by specially trained, competent, qualified, and licensed health professionals consistent with local legal and regulatory statutes. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

It is vital that health professionals who perform conservative sharp debridement or surgical/sharp debridement possess knowledge of anatomy and adequate training and experience.^{11, 15, 17}

7. **Use sterile instruments for conservative sharp and surgical/sharp debridement. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This recommendation is supported by expert opinion. Although clean dressings may be appropriate for pressure ulcer management,² the instruments being used for conservative sharp or surgical/sharp debridement should be sterile.¹

8. **Use conservative sharp debridement with caution in the presence of:**
- immune incompetence,
 - compromised vascular supply, or
 - lack of antibacterial coverage in systemic sepsis (Strength of Evidence = C; Strength of Recommendation = 👍).

Caution: Relative contraindications include anticoagulant therapy and bleeding disorders.

This recommendation is supported by expert opinion from ten clinical practice guidelines.^{1, 2, 11-17, 21}

9. **Refer individuals with Category/Stage III or IV pressure ulcers with undermining, tunneling/sinus tracts, and/or extensive necrotic tissue that cannot be easily removed by other debridement methods for surgical evaluation as appropriate to the individual's condition and goals of care. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This recommendation is supported by expert opinion from nine clinical practice guidelines.^{1, 2, 11, 12, 14-17, 21}

10. **Manage pain associated with debridement. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Surgical, conservative sharp, enzymatic, biological and mechanical forms of debridement may result in pain (Refer to *Pain Assessment and Treatment* section of this guideline.) This recommendation is supported by expert opinion from ten clinical practice guidelines.^{1, 2, 11-17, 21}

11. **Perform a thorough vascular assessment prior to debridement of lower extremity pressure ulcers to determine whether arterial status/supply is sufficient to support healing of the debrided wound. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Surgical/sharp and conservative sharp debridement of avascular tissue should only be performed after adequate perfusion has been established. This recommendation is supported by expert opinion from two clinical practice guideline.^{1, 13} When vascular correction is impossible, the decision on whether to debride should be made between the patient and vascular or wound specialist, in consideration of risks and benefits.

12. Do not debride stable, hard, dry eschar in ischemic limbs. (Strength of Evidence = C; Strength of Recommendation = 👍)

Shannon (2013)⁴² conducted a retrospective review in a nursing home population of heel pressure ulcers (n = 179) with entire eschar (67.8% of the sample) or blister coverage (31.8% of the sample). Of the 155 patients not lost to follow up, 154 of the wounds (99.3%) healed. Of the heel pressure ulcers covered with eschar, 100% of wounds healed with an average healing time of 11 weeks (range 2 to 50 weeks). Complications included one patient who developed osteomyelitis (with eventual healing) and two cases of cellulitis and one eventual amputation in a patient with blister coverage of the ulcer (Level 5 study).

12.1. Assess stable, hard, dry eschar at each wound dressing change and as clinically indicated. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Assessment of an ulcer covered with dry, stable eschar should be performed at each dressing change and as clinically indicated to detect the first signs of any developing infection. Clinical indications that the dry, stable eschar requires assessment and intervention include signs of erythema, tenderness, edema, purulence, fluctuance, crepitus, and/or malodor (i.e., signs of infection) in the area around the dressing.

12.2. Consult a medical practitioner/vascular surgeon urgently in the presence of the above symptoms. (Strength of Evidence = C; Strength of Recommendation = 👍)

12.3. Debride the pressure ulcer urgently in the presence of the above symptoms (i.e, erythema, tenderness, edema, purulence, fluctuance, crepitus, and/or malodour). (Strength of Evidence = C; Strength of Recommendation = 👍)

Supporting expert opinion is expressed in five clinical practice guidelines.^{1, 2, 12, 14, 15}

13. Perform maintenance debridement on a pressure ulcer until the wound bed is free of devitalized tissue and covered with granulation tissue. (Strength of Evidence = C; Strength of Recommendation = 👍)

Maintenance debridement is ongoing debridement to help maintain the wound in a healing mode. Beyond the obvious removal of devitalized tissue, research on other chronic wounds has shown that conservative sharp debridement or surgical debridement in particular effaces the wound bed of excess exudates and disassembles or detaches bacterial colonies (biofilms) and senescent fibroblasts, allowing a stimulatory environment to be established^{4, 5, 10, 11, 19} (indirect evidence). The need for debridement is determined by both clinical parameters and the need to achieve optimal wound bed preparation. In ulcers that appear healthy but do not show evidence of closure, maintenance debridement is indicated.⁴³

While acute wounds may only require an initial debridement (if at all) chronic wounds often require maintenance debridement of the base as well as the non-migratory hyperproliferative epithelial edge.^{4, 5, 10, 11, 19} Continue maintenance debridement until the wound bed is free of devitalized tissue, covered with granulation tissue and progressing towards healing. Maintenance debridement should be resumed in the case of delayed wound healing that suggests presence of biofilm^{18, 22} or with the return of any devitalized tissue or deteriorating granulation tissue (indirect evidence).

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ASSESSMENT AND TREATMENT OF INFECTION AND BIOFILMS

Introduction

Bacteria are present on all skin surfaces. When the primary defense provided by intact skin is lost, bacteria will reside on the wound surface. When the bacteria (by numbers or virulence in relation to host resistance) cause damage to the body, infection is present. An impaired host has a reduced ability to combat bacteria. The number of bacteria and their effect on the host can be categorized as:

- contamination,
- colonization,
- critical colonization/topical infection,
- local infection,
- regional spreading infection/cellulitis and
- sepsis.

Sometimes, microorganisms multiply, invade, and damage tissues, delaying healing, and often cause systemic responses. Infection is present when bacteria present in an ulcer impair wound healing.¹

Pressure ulcers are a consequence of ischemia and are more susceptible to the development of infection² as the tissue does not receive normal nutrition, oxygen, immune cells, antibodies, and antibiotics. In addition, risk factors for pressure ulcer development (e.g., protein calorie malnutrition) compromise the host's defenses. Infection is not common in Category/Stage I or II pressure ulcers, and assessment of infection should focus on Category/Stage III and IV ulcers³ and unstageable pressure ulcers.

Wound infection may be associated with biofilms. Bacterial biofilms are extremely common in the natural environment. They are known to cause chronic inflammation that contributes to the molecular pathologies of many diseases, including periodontal disease, surgical device infections, urinary catheter infections, cystic fibrosis, chronic otitis media, and contact lens associated corneal infections.⁴ Compared to planktonic (free-floating) bacteria, bacteria in biofilms have enhanced resistance to endogenous antibodies and phagocytic cells, as well as by exogenous antibiotics and antiseptics. Approximately 60% of chronic skin wounds contain bacterial biofilms,^{5,6} which suggests that biofilms play important roles in maintaining a chronic inflammation state that ultimately leads to the failure of skin wounds to heal. The terms 'critical colonization' and 'localized infection', which were created to describe wounds that fail to heal even with only low numbers of planktonic bacteria ($\leq 10^5$ CFU/gm), may actually be describing wounds that have biofilms. Removal of biofilms by debridement, and prevention of reformation of biofilms using topical antiseptics or antimicrobial dressings may be the optimal treatment to move chronic wounds out of a chronic inflammatory phase and into a healing repair phase.^{7,8} Further study is needed.

System Consideration

1. **Follow local infection control policies to prevent self-contamination and cross-contamination in individuals with pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Assessment of High Risk Individuals with Pressure Ulcers

1. **Have a high index of suspicion of local infection in a pressure ulcer in the presence of:**
 - lack of signs of healing for two weeks;
 - friable granulation tissue;
 - malodor;
 - increased pain in the ulcer;
 - increased heat in the tissue around the ulcer;
 - increased drainage from the wound;
 - an ominous change in the nature of the wound drainage (e.g., new onset of bloody drainage, purulent drainage);
 - increased necrotic tissue in the wound bed; and/or
 - **pocketing or bridging in the wound bed. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

Wound healing is delayed and/or may be abnormal when pressure ulcers have significant bacterial burden and infection. Bridging is the presence of strands of tissue bridging across the ulcer. Pocketing occurs when granulation tissue is not uniform, or heals from the bottom up to the top. These undulating pockets of open tissue can harbor bacteria (indirect evidence).⁹

Cutting et al. (1994)¹⁰ developed criteria to identify infection in granulating wounds of mixed etiology based on a review of the literature. They categorized their characteristics of infected wounds as traditional criteria; that is, cellulitis, abscess and wound discharge (serous, seropurulent, hemopurulent and pus), as well as additional criteria including discoloration, delayed healing, friable granulation, pain and tenderness, malodor, pocketing and bridging. These criteria were later tested in an observational study investigating application of the criteria to wounds by registered nurses in the clinical setting¹¹ and a Delphi process.¹²

Gardner et al. (2001)¹³ reported on the validity of 12 clinical signs and symptoms of chronic wound infection (i.e., pain, erythema, edema, heat, and purulent exudates) and those specific to open chronic wounds (i.e., serous drainage with concurrent inflammation, delayed healing, discoloration of granulation tissue, friable granulation tissue, pocketing at the base of the wound, malodor and wound breakdown) in a mixture of chronic wounds that included 19 pressure ulcers, three of which were infected. Wounds were assessed by health professionals blinded to wound biopsy and culture results. The most sensitive measures of infection were delayed healing and friable granulation tissue, with a sensitivity of 0.81 (specificity of 0.64). Over 80% of infected ulcers had these signs. Increasing pain, malodor and heat also had specificity over 0.80. Ulcers that were not infected did not have these signs. All (100%) the wounds that had increasing pain or wound breakdown were clinically infected (Level 2 study).

2. **Have a high index of suspicion for the likelihood of infection in pressure ulcers that:**
 - have necrotic tissue or a foreign body present;
 - have been present for a long period of time;
 - are large in size or deep; and/or
 - are likely to be repetitively contaminated (e.g., near the anus). (Strength of Evidence = C; Strength of Recommendation = 👍)

Factors within the pressure ulcer can increase the risk of infection. Necrotic tissue contains high levels of both anaerobic and aerobic bacteria, and in greater density than nonnecrotic ulcers have.^{14, 15} Tarnuzzer et al. (1996)¹⁶ have suggested that bacterial colonization in chronic wounds elevates proinflammatory cytokines, such as interleukin-1 and tumor necrosis factor. This condition in turn increases the levels of matrix metalloproteases (MMPs), decreases the level of inhibitors in tissue against the MMPs, and decreases the production of growth factors and fibroblast activity. Fecal matter contains high levels of bacteria, which can create a heavy bacterial burden in the wound bed.¹⁷

In a retrospective study of surgical samples in infected pressure ulcers, the predominant organisms were *Enterobacter* (29%), *Staphylococci* (28%), and *Enterococcus faecalis* (16%).¹⁸ A cross-sectional prevalence study in Spain reported the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization in pressure ulcers of 1377 participants from nine long term care facilities was 59%.¹⁹

3. Have a high index of suspicion for local wound infection in individuals with:

- **diabetes mellitus,**
- **protein-calorie malnutrition,**
- **hypoxia or poor tissue perfusion,**
- **autoimmune disease, or**
- **immunosuppression. (Strength of Evidence = B; Strength of Recommendation = ⤴)**

The immune response to bacterial infection of individuals with compromised host defenses is less robust than normal. The majority of Category/Stage III and IV pressure ulcers occur in older adults, who often have many co-morbidities that increase the risk of pressure ulcer development and simultaneously impair healing. Gardner et al. (2001)¹³ studied the signs of infection in 19 pressure ulcers known to be infected, as confirmed by quantitative tissue culture. Mean tissue oxygen levels were lower in ulcers with infection (Level 5 study). Tissue ischemia has also been found to be closely linked to postoperative²⁰ and diabetic foot wound infection.²¹

4. Have a high index of suspicion of biofilm in a pressure ulcer that:

- **has been present for more than 4 weeks;**
- **lacks signs of any healing in the previous 2 weeks;**
- **displays clinical signs and symptoms of inflammation;**
- **does not respond to antimicrobial therapy. (Strength of Evidence = C; Strength of Recommendation = ⤴)**

This statement is based on consensus opinion. Biofilm is associated with impaired epithelialization and formation of granulation. When a pressure ulcer has delayed healing (i.e., has been present for four weeks or longer), exhibits clinical signs and symptoms of inflammation and fails to heal despite a standard wound management plan that promotes moist wound healing and/or it does not respond to antimicrobial therapy, the presence of biofilm should be suspected (indirect evidence).^{8, 22-24} In a small diagnostic study including 15 chronic wounds, 60% of the sample had biofilm identified using epifluorescence microscopy. Of these pressure ulcers, all were of greater than four weeks duration and the mean duration was 108 weeks. Only one third of the pressure ulcers showed signs and symptoms of infection⁶ (indirect evidence).

There is currently no confirmed noninvasive, macroscopic method through which presence of biofilm can be visibly identified within the wound bed.^{8, 22-24} The validity of the visual presence in the wound bed of a visible, translucent, thick, slimy film that may be pale yellow or green as a clinical indicator of biofilm is currently debated.^{22, 25, 26}

In one observational study (n = 24 enrolled, n = 16 completed study) macroscopic identification of biofilm was used to assess wound healing associated with a biofilm based wound management plan (debridement and application of polyhexanide and betaine [PHMB]). The researchers defined presence of a shiny, translucent, slimy layer on a non-healing wound surface as indicative of biofilm, and reported statistically significant reduction in macroscopic biofilm over 24 weeks associated with the treatment regimen (61.8 ± 34.6% versus 22.6 ± 36.0% of wound bed, p < 0.01). Although a recognized biofilm based wound management strategy reduced the macroscopic presence of the slime layer, there was no microscopic confirmation that this visual characteristic was attributable to biofilm²⁷ (indirect evidence).

In a case series (n = 9) the researchers reported the presence of a thick, opaque film in chronic wounds with clinical signs of infection, particularly local inflammation. The presence of bacterial burden was confirmed via laboratory swabs in five of the cases. In all cases, reduction or complete eradication of the macroscopic film was only successful with regular wound debridement, and when this was achieved the wounds progressed to healing. Once again, although reduction of the visual film was achieved using a

biofilm based wound management strategy, microscopic diagnosis of biofilm was not made (indirect evidence).²⁸ Further clinical studies are required to confirm whether experienced clinicians are able to visually identify the presence of wound biofilm.

Diagnosis of Infection

- 1. Consider a diagnosis of spreading acute infection if the pressure ulcer has local and/or systemic signs of acute infection, such as:**
 - erythema extending from the ulcer edge;
 - induration;
 - new or increasing pain or warmth;
 - purulent drainage;
 - increase in size;
 - crepitus, fluctuance, or discoloration in the surrounding skin;
 - fever, malaise, and lymph node enlargement; or
 - confusion/delirium and anorexia (particularly in older adults). (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Chronic ulcers can develop into acute spreading infection. There is a more classic appearance of the individual and the wound when acute infection is present.⁹ Older adults often do not develop the usual signs of infection; rather, they may develop confusion or delirium, lose general function and become anorexic.²⁹

- 2. Determine the bacterial bioburden of the pressure ulcer by tissue biopsy or quantitative swab technique. (Strength of Evidence = B; Strength of Recommendation = 👍)**

In the absence of clinical signs of infection, the quantity of organisms (microbial load) is believed to be the best indicator of wound infection. The gold standard method for examining microbial load is quantitative culture of viable biopsied wound tissue. Wound tissue is viewed as the most valid specimen for quantitative tissue culture because tissue biopsies reflect organisms invading the wound, not those contaminating the wound surface. Surface swabs will only reveal the colonizing organism, and may not reflect deeper tissue infection.

In one study, superficial swabs from pressure ulcers (n = 72) were positive for 96% of ulcers tested, whereas the deep tissue aspirates were positive in only 43% of ulcers and deep tissue biopsies were positive in 63% of the same ulcers. Of the 43 pressure ulcers that were assessed using all three methods, 98% screened positive via swab culture, 53% had positive deep tissue aspirate and 63% screened positive using tissue biopsy³⁰ (Level 2 study).

An acceptable alternative to quantitative tissue culture is the Levine quantitative swab technique (described below). Sapico et al. (1986)¹⁵ compared findings from quantitative and swab cultures of pressure ulcers (n = 25) and reported a mean concordance of 74.5%. The concordance between the central and peripheral portions of the ulcer was 63%, indicating that there is some variability in findings based on the location of the sample (Level 2 study). Bill et al. (2001)³¹ reported a 69% concordance between quantitative biopsy and quantitative swab cultures in 39 ulcers, not including pressure ulcers (indirect evidence).

Procedure for performing quantitative swab cultures (Levine method)

- Cleanse wound with normal saline.
- Remove/debride nonviable tissue.
- Wait two to five minutes.
- If ulcer is dry, moisten swab with sterile normal saline.
- Culture the healthiest looking tissue in the wound bed.
- Do not culture exudate, pus, eschar, or heavily fibrous tissue.
- Rotate the end of a sterile alginate-tipped applicator over a 1cm² area for 5 seconds.
- Apply sufficient pressure to swab to cause tissue fluid to be expressed.
- Use sterile technique to break tip of swab into a collection device designed for quantitative cultures.

2.1. Consider using tissue biopsy and microscopy to determine the presence of biofilm. (Strength of Evidence = C; Strength of Recommendation = ⤴)

The current gold standard for confirmation of presence of biofilm is microscopic examination using light microscopy, epifluorescence microscopy or scanning electronic microscopy (SEM).^{22,24} However, the value and cost effectiveness of these techniques in routine clinical management of pressure ulcers is yet to be demonstrated.

In one diagnostic study, wedge tissue biopsies from chronic wounds (n = 15, n = 5 were pressure ulcers) were analyzed using standard culture, gene sequencing and epifluorescence microscopy in order to inform a taxonomy classification of biofilm organisms. Standard culture identified an average of three bacterial species in each sample compared with an average of 17 species identified using gene sequencing. Epifluorescence microscopy identified biofilm in 60% of samples⁶ (indirect evidence). Similarly, in a study in which culture analysis, light microscopy and SEM were used to assess 37 chronic wounds of mixed etiology (n = 21 pressure ulcers), culture identified eight frequently observed bacteria species compared with 15 frequently occurring species identified used microscopy. Sixty percent of the sample contained biofilm⁵ (indirect evidence).

3. Consider a diagnosis of pressure ulcer infection if the culture results indicate bacterial bioburden of $\geq 10^5$ CFU/g of tissue and/or the presence of beta hemolytic streptococci. (Strength of Evidence = B; Strength of Recommendation = 👍)

Wound infection occurs when the virulence factors of one or more wound organisms overwhelm the host's resistance, resulting in invasion and replication of the organism or production of toxin and local tissue damage. Daltrey et al. (1981)³² demonstrated that a microbial load greater than 10^5 organisms per gram of tissue is the critical level for diagnosing infection. Bendy et al. (1964)³³ showed that significant healing of pressure ulcers occurred only when bacterial counts were less than 10^6 . The 10^5 guideline has been questioned based on the assertion that the interactions among specific types of pathogens may be more important than microbial load in promoting bacterial growth and infection. Supporting this assertion is microbiological evidence that chronic leg wounds contain multiple species of microbial organisms and that those that contain four or more different species have poor healing outcomes.³⁴ Nonetheless, it is unclear which organisms represent a definitive threat to the wound environment or which interact with others in a synergistic manner.³⁵

Treatment

1. Optimize the host response by:

- evaluating nutritional status and addressing deficits;
- stabilizing glycemic control;
- improving arterial blood flow; and/or
- reducing immunosuppressant therapy if possible. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Many systemic factors contribute to the development of pressure ulcers. If these same factors can be improved, the individual's intrinsic ability to fight infection can usually also be improved. Review the individual's nutritional intake, modify it if needed and stabilize diabetic glycemic control (see *Nutrition for Prevention and Treatment of Pressure Ulcers* section of the guideline). Assess arterial blood supply to the wound and instigate appropriate management for peripheral arterial disease (e.g., management of blood pressure and cholesterol, encouraging the individual to cease smoking and medical or surgical management as appropriate). If possible, reduce doses of immunosuppressive agents.

2. Prevent contamination of the pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Pressure ulcers near the anus are subject to contamination, especially by bacteria from the colon. Predominant organisms in infected pressure ulcers included *Enterobacter* species, *Proteus* species, *Escherichia coli*, and *Enterococcus faecalis*.¹⁸ Meticulous skin cleansing and use of dressings or topical agents to prevent exposure to fecal matter are needed. At times, bowel management systems and diversion of ostomies are required due to continuous exposure of the ulcer to feces.^{36,37} The *Preventive Skin Care* section of the guideline provides further recommendations on continence management.

3. Reduce bacterial load and biofilm in the pressure ulcer as outlined in the *Wound Care: Cleansing and Wound Care: Debridement* sections. (Strength of Evidence = C; Strength of Recommendation = 👍)

Necrotic tissue and slough promote bacterial growth (see the guideline sections *Wound Care: Cleansing*, *Wound Care: Debridement* and *Surgery for Pressure Ulcers* for associated recommendations). Cleansing removes loose debris and planktonic (free-floating) bacteria. Debridement is often required to remove adherent slough and eschar.

Debridement physically disrupts biofilm growth, providing a window of opportunity in which topical antiseptics can be used more effectively.^{8,23} Once removed, biofilms tend to redevelop. Maintenance debridement should be continued in conjunction with topical antiseptic therapy until the pressure ulcer is clear of biofilm^{7,8} (indirect evidence).

4. Consider the use of tissue appropriate strength, non-toxic topical antiseptics for a limited time period to control bacterial bioburden. (Strength of Evidence = C; Strength of Recommendation = 👍)

Warning: *Hydrogen peroxide is highly toxic to tissues even at low concentrations^{38,39} and should not be used as a preferred topical antiseptic. Its use should be totally avoided in cavity wounds due to the risk of surgical emphysema and gas embolus.³⁹⁻⁴¹*

Caution: *Iodine products should be avoided in patients with impaired renal failure, history of thyroid disorders or known iodine sensitivity.^{42,43} Sodium hypochlorite (Dakin's solution) is cytotoxic at all concentrations and should be used with caution, at concentrations no greater than 0.025%, for short periods only when no other appropriate option is available.⁴⁴⁻⁴⁶ There is a risk of acidosis when acetic acid is used for extended periods over large wound surface areas.⁴⁷*

Antiseptics are agents that destroy or inhibit the growth and development of microorganisms in or on living tissue. Unlike antibiotics that act selectively on a specific target, antiseptics have multiple targets

and a broader spectrum of activity that includes bacteria, fungi, viruses, protozoa, and even prions. Resistance to antiseptics does develop. Antiseptics commonly used in wounds include:

- iodine compounds (povidone iodine and slow-release cadexomer iodine),
- silver compounds (including silver sulfadiazine),
- polyhexanide and betaine (PHMB),
- chlorhexidine,
- sodium hypochlorite, and
- acetic acid.

Cytotoxicity is the main concern when applying a topical agent on an open wound. Antiseptics have been found, primarily using *invitro* models, to be cytotoxic to cells essential to the wound healing process, including fibroblasts, keratinocytes, and leukocytes.^{44, 48, 49} However, this cytotoxicity appears to be concentration dependent, as several antiseptics in low concentrations are not cytotoxic, although they retain their antibacterial activity *invitro*. Care should be taken to protect the periwound area from topical antiseptics and to manage pain associated with application.

When there is a delay in wound healing due to suspected infection antimicrobial use overrides the risk of antiseptic toxicity. Topical antiseptics should be discontinued when infection is managed, or the wound starts to heal, or if the patient experiences any adverse reaction to the agent.⁵⁰

Povidone iodine and cadexomer iodine are low cost topical antiseptic options. *Invitro* studies have found povidone iodine to be toxic to granulocytes in concentrations above 0.05%;^{44, 51} however, animal and clinical studies in mixed etiology wounds have found no reduction in healing rates for povidone iodine in concentrations up to 10% compared with normal saline^{38, 51, 52} (indirect evidence). See the guideline section on *Wound Dressings for Treatment of Pressure Ulcers* for evidence on cadexomer iodine dressings.

Sodium hypochlorite (Dakin's solution) appears to have only short lived (up to 24 hours) antibacterial properties^{53, 54} and there is conflicting evidence on its toxicity to skin cells.⁴⁴⁻⁴⁶ Lineaweaver et al. (1985)⁴⁴ demonstrated there is no concentration of acetic acid that is toxic to bacteria whilst preserving fibroblasts. Its short term use in low concentrations (no greater than 0.025%) should only be considered in the absence of other appropriate topical antiseptics (indirect evidence).

One small (n = 30), randomized controlled trial (RCT) conducted by Wild et al. (2012)⁵⁵ compared topical cleansing with PHMB to normal saline for treating pressure ulcers (half of which were Category/Stage IV pressure ulcers) with known MRSA colonization. After 14 days of treatment, significantly more pressure ulcers in the PHMB group were eradicated of MRSA compared with the control group (100% versus 66.67%, p < 0.05) (Level 2 study). *Invitro* studies support the use of PHMB in concentrations up to 2% as a topical antiseptic for managing *Pseudomonas* species and *S. aureus*^{56, 57} (indirect evidence).

Dilute acetic acid may be of benefit in pressure ulcers infected with *Pseudomonas* species^{9, 58} (indirect evidence).

5. Consider the use of topical antiseptics in conjunction with maintenance debridement to control and eradicate suspected biofilm in wounds with delayed healing. (Strength of Evidence = C; Strength of Recommendation = 👍)

Wolcott et al. (2010)⁸ demonstrated in *invitro* models and a small scale clinical study that less mature biofilm is more susceptible to topical antimicrobial treatment. *Invitro* models demonstrated that biofilm develops tolerance to antibiotic treatment within 24 to 96 hours and suggested that removal of active cells from the surface of biofilm exposes dormant bacteria that have increased susceptibility to treatment. Biofilm samples from venous leg ulcers subjected to conservative sharp debridement showed peak susceptibility to topical antibiotics between 24 hours and 48 hours post debridement. By 72 hours, susceptibility had reduced to that of mature biofilm samples (indirect evidence).

Invitro studies supports the notion that biofilm develops resistance to topical antiseptics as it matures. Numerous studies have demonstrated susceptibility of immature (three days) *S. aureus*, *S. epidermidis*

and *P. aeruginosa* biofilm to povidone iodine in concentrations of 1% to 10%⁵⁹⁻⁶¹ and to cadexomer iodine paste.⁶² Silver sulfadiazine has also been demonstrated to reduce, but not eradicate, colonies of immature biofilm in *invitro* studies^{63, 64} and has been less successful in reducing mature biofilm colonies.⁵⁹ A comparison between iodophors and silver suggested iodophors have a greater role in managing biofilm⁶⁵ (indirect evidence).

A small, uncontrolled study conducted in 16 chronic wounds of mixed etiology described as having macroscopic evidence of biofilm that were managed with 0.3% PHMB impregnated wound dressing showed significant increase in granulation of the wound bed ($p < 0.04$) after 24 weeks of treatment. Seventy-five percent of the wound achieved complete healing⁶⁶ (indirect evidence).

6. Consider the use of topical antiseptics for pressure ulcers that are not expected to heal and are critically colonized/topically infected. (Strength of Evidence = C; Strength of Recommendation = 👉)

Critically colonized or topically infected pressure ulcers are those in which bacteria are present in the tissue, resulting in delayed healing, malodor, and increased exudate from the ulcer.⁶⁷ Recommended strength antiseptics can be used for maintenance ulcers (i.e., those that are not expected to heal) to control bioburden and to reduce inflammation in the ulcer and surrounding skin.¹ See the *Special Populations: Individuals In Palliative Care* section of the guideline for discussion on wound care in individuals whose wound is not expected to heal.

7. Consider use of silver sulfadiazine in heavily contaminated or infected pressure ulcers until definitive debridement is accomplished. (Strength of Evidence = C; Strength of Recommendation = 👉)

Caution: Silver may have toxic properties, especially to keratinocytes and fibroblasts; the extent of the toxicities is not fully described. Topical silver products should not be used on individuals with silver sensitivities, and silver sulfadiazine products are not recommended for people with sulfur sensitivities.⁶⁸

Topical antimicrobial silver offers broad antimicrobial coverage. There is evidence on the use of silver for wound care; however, the majority of studies investigating the use of silver involved burn wounds, leg ulcers, or animal models, and therefore are not directly applicable to pressure ulcers in humans. Strains of bacteria resistant to silver may be emerging (indirect evidence). Silver impregnated dressings are discussed in detail in the *Wound Dressings for Treatment of Pressure Ulcers* section of the guideline.

8. Consider the use of medical-grade honey in heavily contaminated or infected pressure ulcers until definitive debridement is accomplished. (Strength of Evidence = C; Strength of Recommendation = 👉)

Caution: Before applying a honey dressing, ensure the individual is not allergic to honey. Individuals who have bee or bee stings allergies are usually able to use properly irradiated honey products.⁶⁹

Topical medical-grade honey offers broad antimicrobial coverage. A growing body of literature has shown benefit to using medical-grade honey for infected wounds of the leg,^{70, 71} Fournier's gangrene,⁷² and other skin infections. Because honey produces an alternative product for bacterial metabolism that yields lactic acid rather than ammonia, amines, and sulfur (which are odorous) wound odor is reduced. However, no significant research exists on the bactericidal effects of medical-grade honey and the specific bacteria that may be eradicated with honey.^{73, 74}

A recent Cochrane review⁷⁵ identified one small ($n = 40$) RCT⁷⁶ comparing medical-grade honey to saline-soaked gauze for healing Category/Stage I and II pressure ulcers. Although mean time to healing favored the honey treated group ($p =$ not reported), no outcome measures specifically investigated the effect of honey on controlling infection and the pressure ulcers in this study were described as uninfected at baseline (Level 2 study). Biglari et al. (2012)⁷⁷ reported a case series of 20 individuals with spinal cord injury (SCI) and Category/Stage III or IV pressure ulcers that were treated with Medihoney®. After one week of daily cleansing with Ringer's solution and application of 3 mm thick Medihoney®, 90% of the pressure ulcers were void of bacterial growth. However, baseline clinical infection status was not reported in the pressure ulcers (Level 5 study). Gunes and Eser⁷⁸ conducted a RCT with 26 participants

with 68 Category/Stage II and III pressure ulcers. The study compared healing rates in ulcers treated with unprocessed honey that had a minimum inhibitory concentration (MIC) of 3.8%, to those treated with ethoxy-diaminoacridine plus nitrofurazone dressing. Scores on the Pressure Ulcer Scale for Healing Tool (PUSH) were the primary outcome measure. The honey treated group's PUSH scores showed healing at 4 times the rate of the control group ($p < .001$) (Level 5 study).

Manuka honey should be rated UMF (Unique Manuka Factor) +12 or above for topical dressing products. Use medical-grade gamma irradiated honey, as other sterilising processes will destroy the UMF in the honey.⁷⁹

9. Limit the use of topical antibiotics on infected pressure ulcers, except in special situations where the benefit to the patient outweighs the risk of antibiotic side effects and resistance. (Strength of Evidence = C; Strength of Recommendation = 👍)

In general, topical antibiotics are not recommended for treating pressure ulcers. Individuals with pressure ulcers are clearly a high risk group for the acquisition, harboring, and dissemination of antibiotic-resistant organisms. Reasons for this include inadequate penetration for deep skin infections, development of antibiotic resistance, hypersensitivity reactions, systemic absorption when applied to large wounds, and local irritant effects, all of which can lead to further delay in wound healing.

Short courses of silver sulfadiazine, topical antibiotic solutions, or topical metronidazole can be useful in certain circumstances, for example on wounds that have been debrided and cleansed, yet still have a bacterial bioburden of $\geq 10^5$ CFU/g of tissue and/or the presence of beta hemolytic streptococci. These wounds are considered infected⁸⁰ and may benefit from a short course of topical antibiotic guided by culture results and microbial sensitivity.^{1, 2, 81-83}

Topical metronidazole might be used for the treatment of malodor in fungating wounds or wounds with anaerobic infection⁴⁶ (indirect evidence).

10. Use systemic antibiotics for individuals with clinical evidence of systemic infection, such as positive blood cultures, cellulitis, fasciitis, osteomyelitis, systemic inflammatory response syndrome (SIRS), or sepsis. (Strength of Evidence = C; Strength of Recommendation = 👍)

Pressure ulcers are a known cause of sepsis and death.⁸⁴⁻⁸⁷ Abscessed or grossly infected pressure ulcers should be drained and debrided to treat ulcer related sepsis or advancing cellulitis. Systemic antibiotics can reach infected tissue in the base of the pressure ulcer, whereas topically applied agents cannot penetrate through necrotic tissue to reach the wound bed below. Antibiotics should be chosen based on confirmed antibiotic susceptibilities of the suspected or known pathogens. For life-threatening infections, empiric antibiotics should be based on local antimicrobial susceptibility patterns, and re-evaluated when definitive cultures become available^{1, 2, 81-83} (indirect evidence). In some instances, the use of antibiotics may be limited by individual preference or advance directives for end-of-life care.

Judicious use of systemic antibiotics remains an important consideration. In a retrospective study including primarily Category/Stage IV pressure ulcers (56 participants with 115 ulcers) referred for surgical consultation, 4% of pressure ulcers had clinical signs of infection and 13% of participants were positive for MRSA colonization, despite 96% of participants undertaking a course of antibiotics in the preceding two weeks. This study highlighted the issue of over prescription of antibiotics and development of antibiotic-resistant bacterial strains.⁸⁸ Cataldo et al. (2011)⁸⁹ reported a prevalence rate of 15% for MRSA in a convenience sample of older adults with at least Category/Stage III pressure ulcers ($n = 32$) in home care in Italy. Almost 38% of the participants had received systemic antibiotic therapy in the preceding 90 days. In a retrospective study conducted in participants ($n = 145$) in a Brazil hospital who had Category/Stage II or greater pressure ulcers, 43.5% of participants had a MRSA colonized pressure ulcer and 8.3% had MRSA bacteremia. Approximately 57% of the participants had received at least two classes of antibiotics in the preceding 30 days⁹⁰ (Level 4 study).

11. Drain local abscesses. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Local abscesses, the collection of pus, should be incised and drained to prevent local or systemic spread of the infection.

12. Evaluate the individual for osteomyelitis if exposed bone is present, the bone feels rough or soft, or the ulcer has failed to heal with prior therapy. (Strength of Evidence = C; Strength of Recommendation = 👍)

Osteomyelitis has been reported in up to 32% of individuals with pressure ulcers.⁹¹⁻⁹³ Diagnostic assessments may include plain film X-rays, elevated white counts, elevated erythrocyte sedimentation rate (ESR), bone scans, magnetic resonance imaging (MRI), and biopsy, depending on the clinical situation.

Growing research has shown some benefits of using MRI for the diagnosis of osteomyelitis, although there is insufficient evidence on which to base definitive recommendations.⁹⁴⁻⁹⁶ A retrospective review of 41 MRI scans conducted on 37 participants with pressure ulcers showed a significant association between an intermediate to high probability of osteomyelitis and both cortical bone erosion (Pearson's $r = 0.84$) and abnormal bone marrow edema (Pearson's $r = 0.82$). There was high interrater agreement ($\kappa = 0.92$, 95% confidence interval [CI] 0.84 to 1.01, $p < 0.0001$) between radiographers on the likelihood of osteomyelitis⁹⁴⁻⁹⁶ (Level 5 study). However, a retrospective case-controlled study of individuals ($n = 65$) with osteomyelitis undergoing flap reconstruction determined that a diagnostic preoperative MRI scan did not significantly alter clinical or surgical management of the individual, nor patient outcomes compared to diagnosis through bone cultures taken during the surgical procedure⁹⁷ (Level 5 study).

Permanent healing of the pressure ulcer is unlikely until osteomyelitis is controlled. Treatment of osteomyelitis is beyond the scope of these guidelines.

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WOUND DRESSINGS FOR TREATMENT OF PRESSURE ULCERS

Introduction



Wound dressings are a central component of pressure ulcer care. Since the 1960s, it has been accepted that wound healing is optimized when the wound is kept in a moist environment rather than air-dried or dried with heat lamps or topically applied drying agents.¹ Occlusive or semi-occlusive wound dressings that maintain wound bed moisture promote re-epithelialization and wound closure. Wound dressings for pressure ulcers are designed to:

- improve wound healing time;
- absorb blood and tissue exudate;
- minimize pain associated with application and removal;
- absorb and control malodor; and
- reduce injury to periwound skin.

Recently, the role of dressings in protecting skin at high risk of pressure ulcers from shear has received an increased focus in clinical practice and research. Recommendations on the use of prophylactic dressings are outlined in *Emerging Therapies for Prevention of Pressure Ulcers*. Recommendations on negative pressure wound therapy (NPWT) are found in the *Biophysical Agents in Pressure Ulcer Treatment* section of the guideline.

General Recommendations

1. Select a wound dressing based on the:

- ability to keep the wound bed moist;
- need to address bacterial bioburden;
- nature and volume of wound exudate;
- condition of the tissue in the ulcer bed;
- condition of periulcer skin;
- ulcer size, depth and location;
- presence of tunneling and/or undermining;
- goals of the individual with the ulcer. (Strength of Evidence = C; Strength of Recommendation =  )

This statement is based on expert opinion. When the pressure ulcer is clean and granulating, maintenance of a moist wound bed is an important factor in promoting healing or closure. A dressing that remains in contact with the wound bed or a skin barrier product keeps the periwound dry and prevents maceration. As the ulcer either heals or deteriorates over time, the type of wound dressing most appropriate for promotion of healing may change. For example, exudate usually decreases as the pressure ulcer heals. Several moisture-retentive dressings are available.

2. Protect peri-ulcer skin. (Strength of Evidence = C; Strength of Recommendation =)

This statement is based on expert opinion. Care of skin surrounding the pressure ulcer is outlined in the *Wound Care: Cleansing* section of the guideline.

3. Assess pressure ulcers at every wound dressing change and confirm the appropriateness of the current dressing regimen. (Strength of Evidence = C; Strength of Recommendation =)

This statement is based on expert opinion. See the guideline section *Assessment of Pressure Ulcers and Monitoring of Healing* for detailed information on assessing pressure ulcers.

4. Follow manufacturer recommendations, especially related to frequency of dressing change. (Strength of Evidence = C; Strength of Recommendation =)

5. **Change the wound dressing if feces seep beneath the dressing. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Entry of feces into the direct wound healing environment increases the risk for infection.

6. **The plan of care should guide usual dressing wear times and contain provisional plans for dressing changes as needed (for family, the individual, and staff) due to soilage, loosening, etc. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

7. **Ensure all wound dressing products are completely removed with each dressing change. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. See the guideline sections *Wound Care: Cleansing Wound Care: Debridement* for guidance on preparing the wound bed for dressing application.

Hydrocolloid Dressings

1. **Use hydrocolloid dressings for clean Category/Stage II pressure ulcers in body areas where they will not roll or melt. (Strength of Evidence = B; Strength of Recommendation = 👍)**
2. **Consider using hydrocolloid dressing on noninfected, shallow Stage III pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = 👉)**
3. **Consider using filler dressings beneath hydrocolloid dressings in deep ulcers to fill in dead space. (Strength of Evidence = B; Strength of Recommendation = 👍)**
4. **Carefully remove hydrocolloid dressings on fragile skin to reduce skin trauma. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

Hydrocolloid dressings are a common treatment for Category/Stage II pressure ulcers due to their long wear time. The manufacturing of these dressings has advanced, with improvements in the adhesion of dressing edges, addition of antimicrobials to the gel, and development of wound dressing shapes designed for specific anatomical locations. (e.g., heel, sacrum). When dressings were taped to a “hydrocolloid window” around surgical wounds (rather than directly to the skin), Milne et al. (1999)² found less damage to periwound skin.

The evidence statement for the use of hydrocolloid dressings for the treatment of pressure ulcers is derived from three meta-analyses comparing hydrocolloid dressing with paraffin gauze and wet-to-dry gauze dressings. Singh et al. (2004)³ (Level 3 study) analyzed the effect of gauze versus hydrocolloid dressing in pressure ulcers and venous ulcers, and reported that treatment with hydrocolloid dressing resulted in a statistically significant improvement in the complete healing rate of pressure ulcers. In a meta-analysis of five trials, Bradley et al. (1999)⁴ concluded that hydrocolloid dressings led to statistically significant improvement in the rate of pressure ulcer healing when compared to traditional treatments. The results from a meta-analysis by Bouza et al. (2005)⁵ showed that hydrocolloid dressings improve healing of pressure ulcers when compared to traditional forms of gauze. However, the effect size was small and there was no difference between the healing rates of hydrocolloid dressings and more advanced forms of dressings for pressure ulcers.⁵ Today, this information is well-accepted, and wet-to-dry dressings are seldom used because their continuous mechanical debridement prevents healing.

Belmin et al. (2002)⁶ conducted an open, randomized, multiple-center, parallel group trial to compare sequential treatment with calcium alginate and hydrocolloid dressings in 110 participants with non-infected and granulating Category/Stage III or IV pressure ulcers. The healing rate was more rapid in the pressure ulcers treated with calcium alginate first, compared to the group treated with hydrocolloid dressings alone (Level 1 study). Graumlich et al. (2003)⁷ conducted an eight week single-blinded randomized controlled trial (RCT) in 65 participants with Category/Stage II or III pressure ulcers,

comparing collagen and hydrocolloid dressings. There was no difference in complete healing between the two groups. However, there was no stratification based on initial ulcer size (Level 2 study).

Clinical utility of hydrocolloid dressings has been reported, including indications as to their conformance (tested on the heels), absorbency, adhesion, and ease of removal. Bale et al. (1997)⁸ compared hydrocolloid to foam dressings and concluded that there was no difference in mean wear time (Level 2 study). Brown-Etris et al. (2008)⁹ compared hydrocolloids to film dressings containing an absorptive pad, and concluded that the films were more easily placed, removed, and conformable (Level 1 study). Baxter (2000)¹⁰ (Level 5 study) and Brown-Etris et al. (2008)⁹ reported on the removability of hydrocolloid dressings, addressing the issues with patches of adhesive and dressing remaining on the skin.

Transparent Film Dressings

1. Consider using film dressings for autolytic debridement when the individual is not immunocompromised. (Strength of Evidence = C; Strength of Recommendation = ⚡)
2. Consider using film dressings as a secondary dressing for pressure ulcers treated with alginates or other wound filler that will likely remain in the ulcer bed for an extended period of time (e.g., 3 to 5 days). (Strength of Evidence = C; Strength of Recommendation = ⚡)
3. Carefully remove film dressings on fragile skin to reduce skin trauma. (Strength of Evidence = C; Strength of Recommendation = 👍👍)
4. Do not use film dressings as the tissue interface layer over moderately to heavily exuding ulcers. (Strength of Evidence = C; Strength of Recommendation = 👎)
5. Do not use film dressings as the cover dressing over enzymatic debriding agents, gels, or ointments. (Strength of Evidence = C; Strength of Recommendation = 👎)

These recommendations are based on expert opinion. Film dressings were originally designed to cover intact skin over intravenous puncture sites. The transparency of these dressings allows inspection of the skin beneath. Plain film dressings do not absorb drainage from a wound bed. Brown-Etris et al. (2008)⁹ compared hydrocolloids to film dressings containing an absorptive pad, and concluded that the films were more easily placed and removed and were conformable. The Wound Ostomy and Continence Nurses Society (WOCNS) and Agency for Health Care Policy and Research (AHCPR) guidelines address the role of film dressings for autolytic debridement.^{11, 12} As outlined in the guideline section *Wound Care: Debridement*, this form of debridement is commonly performed with film dressings to allow easy wound monitoring. There is little other research on the use of film dressings for treating pressure ulcers.

Hydrogel Dressings

1. Consider using hydrogel dressings on shallow, minimally exuding pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = 👍)
2. Consider using amorphous hydrogel for pressure ulcers that are not clinically infected and are granulating. (Strength of Evidence = B; Strength of Recommendation = 👍)
3. Consider using hydrogel dressings for treatment of dry ulcer beds. (Strength of Evidence = C; Strength of Recommendation = 👍)
4. Consider using hydrogel dressings for painful pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)
5. Consider using hydrogel sheet dressings for pressure ulcers without depth and contours and/or on body areas that are at risk for wound dressing migration. (Strength of Evidence = C; Strength of Recommendation = 👍)

- 6. Consider using amorphous hydrogel for pressure ulcers with depth and contours and/or on body areas that are at risk for dressing migration. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Hydrogel dressings contain hydrated hydrophilic polymers, which produce a moist environment that promotes wound healing. The increase in moisture in the wound bed facilitates autolytic debridement. Other advantages to hydrogel dressings are reductions in:

- wound pain, as gels do not adhere to the wound surface;
- time taken to perform dressings changes; and
- frequency of dressing changes.

The two most common types of hydrogels are amorphous hydrogels and sheet hydrogels. Amorphous gels are clinically preferred for pressure ulcers where the wound dressing is likely to be displaced (e.g., on gravity-dependent body areas such as the lower leg). Hydrogel sheets are clinically preferred for ulcers on nonmoving and nondependent body surfaces.

Little formal study of hydrogels could be found. These recommendations are based on evidence from one Level 2 study and expert opinion. Matzen et al. (1999)¹³ randomly assigned amorphous hydrogel or a continuously wet dressing in 32 participants with non-infected Category/Stage III or IV pressure ulcers on the sacrum or trochanter. Despite a large loss of sample size, wound volume was significantly smaller in the hydrogel group ($p < 0.02$). The hydrogel-treated group also needed necrotic tissue to be debrided from the wound ($p < 0.03$) on significantly fewer occasions (Level 2 study).

Alginate Dressings

- 1. Consider using alginate dressings for the treatment of moderately and heavily exuding pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = 👍)**
- 2. Consider using alginate dressings in clinically infected pressure ulcers when there is appropriate concurrent treatment of infection. (Strength of Evidence = C; Strength of Recommendation = 👍)**
- 3. Gently remove the alginate dressing, irrigating it first to ease removal if necessary. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
- 4. Consider lengthening the interval between wound dressing changes or changing the type of wound dressing if the alginate dressing is still dry at the scheduled time for dressing change. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Alginate is able to absorb exudate and maintain ulcer bed moisture. Alginate dressings can often be left on an ulcer for several days, thereby decreasing frequency of dressing changes. Alginate dressings are manufactured in sheet and rope forms. The clinical choice between alginate sheet and rope dressings is based on the depth and shape of the ulcer. Residual alginate fibers are not biodegradable; therefore they should be completely removed from the ulcer bed. See the guideline section *Wound Care: Cleansing* and *Wound Care: Debridement* for recommendations on cleaning the wound bed in preparation for a wound dressing application.

The recommendations are derived from two RCTs. Belmin et al. (2002)⁶ reported that ulcer surface area of Category/Stage II and III pressure ulcers in geriatric participants was statistically significantly reduced in size with an alginate dressing for four weeks, followed by a hydrocolloid dressing for four weeks, when compared to use of a hydrocolloid dressing alone for eight weeks (Level 2 study). Sayag et al. (1996)¹⁴ conducted a RCT with 92 participants, and also reported that mean healing time was reduced in full thickness pressure ulcers when treated with alginate, compared to dextranomer paste (Level 2 study).

Because alginates have minimal antimicrobial properties they are generally not used as the primary or only treatment for infected ulcers. Treatment of infected pressure ulcers is discussed in the *Assessment and Treatment of Infection and Biofilms* section of the guideline.

Foam Dressings

1. Consider using foam dressings on exuding Category/Stage II and shallow Category/Stage III pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = 👍)
2. Avoid using single small pieces of foam in exuding cavity ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)
3. Consider using gelling foam dressing in highly exuding pressure ulcers. (Level of Evidence C; Strength of Recommendation = 👍)

Foam dressings absorb wound exudate from the pressure ulcer bed. Simple foam dressings wick exudate from the wound bed and translocate it to the surface of the wound dressing. Complex foam dressings absorb wound exudate by dispersing it throughout the wound dressing for retention away from the skin. Gelling foam dressings manage excess wound exudate and protect surrounding skin from prolonged exposure to wound or body fluids. Foam dressings also promote moisture evaporation, thereby allowing more drainage to be wicked away from the wound bed and surrounding skin.

Bale et al. (1997)⁸ compared hydrocolloid dressings to foam dressings and concluded that the latter managed exudate more effectively, although there was no significant difference in wound dressing wear time. Clinical uses of foam dressings also include application as a cover dressing to extend wear time (Level 2 study).

Diehm et al. (2005)¹⁵ reported a descriptive study of 6,693 participants with chronic exuding ulcers of multiple types, including 1,793 participants with pressure ulcers. Only 4.5% of the ulcers were classified as superficial in this group, and 49% were described as infected. The ulcers were managed with a hydropolymer dressing. At four weeks, there was a 67% reduction in ulcer radius; 39% of the pressure ulcers had healed, and 56% were improved. At 12 weeks, there was an 87.5% reduction in wound radius, with 58% healed and 43.9% improved (Level 5 study).

Parish et al. (2008)¹⁶ conducted a small quasi-experimental study (n = 23) of an adhesive, gelling foam dressing. At 28 days, 4% of pressure ulcers were described as healed, 30% had a marked improvement, 26% showed mild improvement, 4% had mild deterioration and 9% were markedly deteriorated (Level 5 study).

Silver-Impregnated Dressings

1. Consider using silver-impregnated dressings for pressure ulcers that are clinically infected or heavily colonized. (Strength of Evidence = B; Strength of Recommendation = 👍)
2. Consider using silver-impregnated dressings for ulcers at high risk of infection. (Strength of Evidence = B; Strength of Recommendation = 🤔)
3. Avoid prolonged use of silver-impregnated dressings. Discontinue silver dressings when wound infection is controlled. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Caution: Topical silver products should not be used on patients with silver sensitivities. Silver may have toxic properties, especially to keratinocytes and fibroblasts; the extent of the toxicities has not been fully described.

There are several forms and formulations of silver-impregnated dressings available for wound care. This section of the guideline addresses wound dressings that are impregnated with silver. The use of topical silver sulfadiazine is discussed in the guideline section *Assessment and Treatment of Infection and Biofilms*.

Metallic silver is relatively inert, but the presence of liquid leads to the release of the silver ion responsible for its biological activity. Silver ions are biocidal at very low concentrations due to the ability

of microbial cells to absorb and concentrate silver from very dilute solutions. However, the presence of organic matter significantly diminishes the efficacy of silver. The efficacy of silver dressings remains to be confirmed in the presence of devitalized tissues in a wound bed.

The study of silver dressings in pressure ulcers is still being debated due to the misperception of direct cost effectiveness. The primary aim of treatment with a silver dressing is to reduce bioburden.¹⁷ There is currently little scientific literature upon which to base recommendations on the use of silver in wound care. The studies reported below used silver dressings for a maximum of four weeks.

Vermeulen et al. (2007)¹⁸ conducted a Cochrane systematic review and reported that silver dressings did not lead to pressure ulcer healing. The reviewers confirmed that silver dressings were associated with a reduction in ulcer area. Munter et al. (2006)¹⁹ studied 619 participants with chronic ulcers, including 46 individuals with pressure ulcers. They reported greater reduction in wound area with a silver foam dressing (58.5%, compared with 33.3% for local best practice), less maceration, better handling of exudate, and faster reduction of odor (Level 3 study).

A recent RCT by Trial et al. (2010)²⁰ that included 42 participants with pressure ulcers showing one or more symptoms of local infection, compared outcomes of ionic silver alginate matrix with that of a silver-free alginate dressing. While the silver dressing appeared to improve the bacteriological status of the wounds, this trial was underpowered to measure clinical effectiveness, and further trials are needed to demonstrate a positive impact on the healing process (Level 2 study).

Chuangsuwanich et al. (2011)²¹ conducted a low quality randomized trial with 40 participants comparing silver mesh dressings (n = 20) with silver sulfadiazine cream (n = 20). There was no significant difference (p = 0.093) in reduction in pressure ulcer area between the two types of silver treatments after eight weeks. The cost of silver mesh dressings was reported to be cheaper (Level 2 study).

Beele et al. (2010)²² compared a silver alginate/carboxymethyl-cellulose antimicrobial wound dressing with a non-silver calcium alginate dressing over four weeks. Participants (n = 36, only n = 12 had pressure ulcers) were considered at risk of infection as assessed using the mASEPSIS tool (a tool in which Likert scores are used to assess signs and symptoms indicative of infection). Beele et al. (2010)²² reported significant reduction in overall wound surface area (p = 0.017 between wound dressing types). A reduction in mASEPSIS scores was found for the silver alginate dressing, but this was not significantly different from the outcomes observed for the non-silver dressing (indirect evidence).

It is important to acknowledge that silver dressings are intended to reduce bioburden^{20, 22} and their use should be discontinued once the pressure ulcer is healing. Silver-resistant strains of bacteria may be emerging. The prophylactic use of a silver dressing as a barrier to microorganisms in wounds at high risk of infection or re-infection should be carefully considered and clearly documented.

Honey Impregnated Dressings

1. **Consider using dressings impregnated with medical-grade honey for the treatment of Category/Stage II and III pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = ⤵)**

Caution: Before applying a honey dressing, ensure the individual is not allergic to honey. Individuals who have bee or bee stings allergies are usually able to use properly irradiated honey products.²³

Honey-impregnated dressings should be compared to alginates, hydrocolloids, silver and other advanced topical treatments for pressure ulcers. Honey produces hydrogen peroxide (H₂O₂), contains antioxidants, and releases anti-inflammatory products. Odor is reduced because the honey produces an alternative product for bacterial metabolism that yields lactic acid rather than ammonia, amines, and sulfur, which are odorous. Gunes and Eser²⁴ conducted a RCT with 26 participants with 68 Category/Stage II and III pressure ulcers. The study compared healing rates in ulcers treated with unprocessed honey with a minimum inhibitory concentration (MIC) of 3.8%, to those treated with ethoxy-diaminoacridine plus a nitrofurazone dressing. The primary outcome measure was Pressure Ulcer Scale for Healing (PUSH) tool

scores. The honey-treated group's mean PUSH tool score showed healing at four times the rate of the control group ($p < .001$) (Level 5 study).

The use of medical-grade honey as a topical agent under a dressing (i.e., not a honey impregnated dressing) is discussed in the *Assessment and Treatment of Infection and Biofilms* section of this guideline.

Cadexomer Iodine Dressings

1. Consider using cadexomer iodine dressings in moderately to highly exuding pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)

Caution: Iodine products should be avoided in individuals with impaired renal failure, history of thyroid disorders or known iodine sensitivity.^{25, 26} It is not recommended for individuals taking lithium, or for pregnant or breast-feeding women. Iodine toxicity has been reported in a few case studies, especially in those individuals with large wounds, in whom dressings were changed often. The risk of systemic absorption increases when iodine products are used on larger, deeper wound or for prolonged periods.

Cadexomer iodine consists of spherical hydrophilic beads of cadexomer starch that contain iodine, are highly absorbent, and release iodine slowly in the wound area. It is available as an ointment, a wound dressing and as a powder. Moberg et al. (1983)²⁷ (Level 2 study) conducted a randomized controlled trial on 34 participants with pressure ulcers, comparing cadexomer iodine with standard treatment. Cadexomer iodine significantly reduced pus, debris, and pain of the ulcers and accelerated the healing rate. After eight weeks of treatment, ulcer area was reduced by 76% and 57% in the cadexomer iodine and standard treatment groups, respectively. Six ulcers treated with cadexomer iodine were completely healed, while only one with standard treatment was healed.

Gauze Dressings

1. Avoid using gauze dressings for open pressure ulcers that have been cleansed and debrided because they are labor-intensive, cause pain when removed if dry, and lead to desiccation of viable tissue if they dry. (Strength of Evidence = C; Strength of Recommendation = 👍)

Caution: Avoid use of wet-to-dry gauze dressings.

2. When other forms of moisture-retentive dressing are not available, continually moist gauze is preferable to dry gauze. (Strength of Evidence = C; Strength of Recommendation = 👍)
3. Use gauze dressings as the cover dressing to reduce evaporation when the tissue interface layer is moist. (Strength of Evidence = C; Strength of Recommendation = 👍)
4. Use loosely woven gauze for highly exuding ulcers; use tightly woven gauze for minimally exuding ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)
5. Loosely fill (rather than tightly pack) ulcers with large tissue defects and dead space with saline-moistened gauze when other forms of moisture-retentive dressing are not available, to avoid creating pressure on the wound bed. (Strength of Evidence = C; Strength of Recommendation = 👍)
6. Change gauze packing often enough to manage exudate. (Strength of Evidence = C; Strength of Recommendation = 👍)
7. Use a single gauze strip/roll to fill deep ulcers; do not use multiple gauze dressings, because retained gauze in the ulcer bed can serve as a source of infection. (Strength of Evidence = C; Strength of Recommendation = 👍)
8. Consider using impregnated forms of gauze to prevent evaporation of moisture from continuously moist gauze dressings. (Strength of Evidence = C; Strength of Recommendation = 👍)

Gauze dressings are made of cotton or synthetic fabric that is absorptive and permeable to water, water vapor and oxygen. Practice varies widely in relation to gauze dressings. Increased infection rates, retained dressing particles, and pain have led health professionals in some geographic regions to avoid the use of gauze dressings for open chronic wounds such as pressure ulcers, in favor of advanced wound dressings. Several studies have demonstrated faster healing rates with advanced dressings when compared to saline-moistened gauze^{3, 13} or only a dry gauze.²⁸

If used, gauze may be used dry; moist; or impregnated with paraffin, petrolatum, antiseptics, or other agents. It is manufactured in varying weaves, and with different size interstices. Gauze dressings today are fairly limited and primarily used as surgical dressings. Due to the need for frequent changes, they have been shown to be costly in health professional time.^{29, 30} Although the use of saline impregnated or moistened gauze is preferable to allowing the ulcer to desiccate, the formulary should provide access to advanced wound dressing options.

Silicone Dressings

1. **Consider using silicone dressings as a wound contact layer to promote atraumatic dressing changes. (Strength of Evidence = C; Strength of Recommendation = 👍)**
2. **Consider using silicone dressings to prevent periwound tissue injury when periwound tissue is fragile or friable. (Strength of Evidence = B; Strength of Recommendation = 👍)**

Silicone is chemically inert, and adverse effects from the use of silicone in wound care are rare. Since silicone is inert, it does not chemically interact with the wound. Silicone is insoluble in wound exudate. Silicone dressings are designed to provide a wound contact layer that can be removed without causing trauma to the tissues or pain for the individual. These dressings can also protect friable or newly healed periwound tissue from injury during dressing changes. Meaume et al. (2003)³¹ conducted a RCT with 38 participants with Category/Stage II pressure ulcers comparing an adherent foam dressing to a silicone dressing. The silicone dressing was found to be less traumatic to the periwound tissue (Level 2 study).

Collagen Matrix Dressings

1. **Consider using collagen matrix dressings for nonhealing Category/Stage III and IV pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 🤔)**

Collagen is the most prevalent body protein and has been shown to be degraded in chronic wounds by proteases and elastase. Collagen matrix dressings are manufactured from bovine, porcine, or avian collagen and made in sheets and pads, as particles, and as gels.

The application of collagen has been shown to reduce the levels of proteases in chronic wounds.³² One RCT on collagen dressings and pressure ulcers found no difference in healing rates between ulcers treated with collagen matrix and those treated with a viscose rayon dressing³² (Level 2 study).

There is one well-designed RCT comparing collagen to hydrocolloid dressings in 65 subjects with 65 Category/Stage II and III pressure ulcers⁷ (Level 2 study). After adjusting for baseline depth, there was no significant difference in primary or secondary healing between the groups. Mean healing time in the collagen group was five weeks, compared to six weeks in the hydrocolloid group. Mean linear healing rate of the wound bed was three mm in both groups. Collagen was more expensive than hydrocolloid and required more nursing interventions per week. The ideal individual and ulcer to benefit from collagen dressings is yet to be elucidated.

Composite Dressings

Many of the dressing types listed here are manufactured in combinations. Please refer to the statements about the individual components when considering the use of composites.

Various composite dressings with new components for specific purposes emerge in the wound dressing market. For example, recent research²⁸ conducted on the effectiveness of an advanced composite dressing containing chitosan (derived from sea crustacean) and polysaccharide alginate showed reduction in size for Category/Stage I to IV pressure ulcers treated for 21 days. The study had methodological limitations, including a high drop-out rate without intention-to-treat analysis and the product is currently not widely available, having been developed in Iran for military use (Level 2 study).

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BIOLOGICAL DRESSINGS FOR THE TREATMENT OF PRESSURE ULCERS


Introduction

Biological dressings function as protective wound cover and may be cellular (contain living cells) or acellular (biologically inert). They can be composed of: ¹

- animal (bovine or porcine) material,
- human (cadaveric skin) cells,
- plant (cellulose) materials,
- synthetic (man-made) material, or
- be a composite (mix of materials of various origin).

Biological dressings include skin substitutes, xenografts, allografts or collagen dressings. These dressings may function as biological modulators, influencing biological processes.¹

Recommendations

1. **Due to insufficient evidence to support or refute the use of biological dressings in the treatment of pressure ulcers, biological dressings are not recommended for routine use at this time. (Strength of Evidence = C; Strength of Recommendation = )**

One randomized, controlled, pilot study conducted in patients with Category/Stage III pressure ulcers of at least four weeks duration (n = 10) demonstrated that a collagen wound dressing was associated with a significant positive effect on angiogenesis (p < 0.05) compared with a foam wound dressing. After 21 days of second-daily dressings, 100% of the pressure ulcers treated with collagen wound dressing were healed, compared with 80% treated with the foam wound dressing (Level 2 study).² Studies conducted in individuals with diabetic (neurotrophic) foot ulcers³ and mixed etiology chronic wounds⁴ have demonstrated positive wound healing outcomes associated with biological dressings, including a bi-layered cell therapy wound dressing and a hyaluronic acid derivative wound dressing (indirect evidence).

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GROWTH FACTORS FOR THE TREATMENT OF PRESSURE ULCERS

Introduction

The role of growth factors in the cellular and biochemical events that occur during wound healing includes regulation of cell proliferation and differentiation. Recombinant deoxyribonucleic acid (DNA) technology has been used to produce a recombinant human platelet-derived growth factor (rPDGF, rPDGF-BB, or rhPDGF-BB).

Platelet-rich plasma (also known as platelet-enriched plasma, platelet-rich concentrate, autogenous platelet gel, or platelet releasate) is used by placing supraphysiologic concentrations of autologous platelets at the site of tissue damage. Blood is drawn from the individual and centrifuged to create platelet-rich plasma that is applied to the wound.

Numerous growth factors have been investigated for healing of pressure ulcers including:

- recombinant platelet-derived growth factor (rPDGF)¹⁻⁵ (Level 2 studies);
- basic fibroblast growth factor (bFGF)⁶ (Level 3 study);
- granulocyte-macrophage colony-stimulating factor (GM-CSF)⁷ (Level 2 study);
- nerve growth factor (NGF)⁸ (Level 2 study);
- interleukin-1 beta (IL-1 β)⁹ (Level 2 study);
- transforming growth factor beta-3 (TGF- β 3)¹⁰ (Level 2 study);
- autologous platelet factors; and
- bone marrow nuclear cells¹¹ (Level 5 study).

Recombinant Platelet-Derived Growth Factor

1. **Consider using platelet-derived growth factors for treatment of Category/Stage III and IV pressure ulcers that have delayed healing. (Strength of Evidence = B; Strength of Recommendation = \Rightarrow)**

Three phase II clinical studies reported significantly improved healing of pressure ulcers treated with rPDGF.^{1, 3-5} In a multi-centered, double blinded randomized controlled trial (RCT) conducted by Rees et al. (1999)³ participants (n = 124) with Category/Stage III or IV pressure ulcers were treated with becaplermin gel (a rPDGF) in doses of either 100 μ g/g or 300 μ g/g. The control group was treated with a placebo gel. Pressure ulcers treated with rPDGF were more likely to achieve complete healing compared with those treated with placebo gel (placebo gel 0%; 100 μ g/g daily 23%, p = 0.005; 300 μ g/g daily 19%, p = 0.008). Significant findings were also achieved for other wound healing end points including median relative pressure ulcer volume (Level 1 study).

Another double blind RCT (n = 20) demonstrated superiority of rPDGF-BB 100 μ g/g in achieving reduction in wound depth at 29 day follow up for Category/Stage III and IV pressure ulcers of up to 67 months duration compared with a placebo gel (14.1 \pm 7.4% of day 0 depth versus 34.9 \pm 6.7% of day 0 depth, p \leq 0.05). However, the findings were not significant for reduction in wound volume (Level 2 study).^{4, 5}

Mustoe et al. (1994)¹ compared 300 μ g/ml aqueous rPDGF-BB (n = 12); 100 μ g/ml aqueous rPDGF-BB (n = 15) and saline-soaked gauze dressings (n = 14) in a multi-center RCT. The rPDGF-BB was associated with superior reduction in wound volume after 29 days compared with saline dressings. However, this study was small and had a high participant drop out (n = 11) that may have influenced the findings (Level 2 study). In a secondary analysis² of a subset of the participants in this trial (n = 20), laboratory analyses demonstrated a significant increase in fibroblast content in pressure ulcers treated with rPDGF-BB compared with placebo (2.81 \pm 0.17 versus 2.05 \pm 0.24, p = 0.0) (indirect evidence). Process for selection of participants for this secondary analysis was not reported.

Other Growth Factors

1. **Due to insufficient evidence to support or refute the use of growth factors (other than recombinant platelet-derived growth factor) in the treatment of pressure ulcers they are not recommended for routine use at this time. (Strength of Evidence = C; Strength of Recommendation = ↗)**

Robson et al. (2000)⁷ conducted a phase II study (n = 61) comparing effectiveness of a range of growth factor treatments (GM-CSF alone, bFGF alone and sequential GM-CSF/bFGF) with placebo for treating Category/Stage III or IV pressure ulcers. At 36 day follow up, there was no statistically significant difference between any single treatment and placebo for reduction in wound volume or percent wound closure. When the growth factor groups were combined, significantly more (p = 0.03) of those participants achieved at least an 85% reduction in wound volume compared with placebo (Level 2 study).

A double blinded RCT (n = 26) investigated IL-1 β in three doses for healing pressure ulcers with a baseline volume of between 10 and 100 cm³. There was no significant difference compared with placebo in decrease in wound volume at 29 day follow up (Level 2 study).⁹

In a small RCT (n = 16), allogeneic platelet gel was shown to trigger early healing (onset of granulation tissue proliferation) in the first two weeks of treatment compared with control treatments (a range of iodine based dressings or negative pressure wound therapy), but no prolonged advantage was observed (Level 2 study).¹² Platelet-rich plasma gel was also used in two case series^{13, 14} that both demonstrated improvements in wound area and volume and reduction in undermining/sinus tracts after two weeks of treatment (Level 5 studies). None of these studies followed through to wound closure.

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BIOPHYSICAL AGENTS IN PRESSURE ULCER TREATMENT

Introduction

Biophysical agents can be used to deliver specific treatment substances to the wound bed. These substances include oxygen via positive (hyperbaric or hyperatmospheric) pressure.

The electromagnetic spectrum (EMS) is an energy source that affects living systems. The EMS comprises infrared (thermal radiation), ultraviolet light (invisible light), laser (coherent and monochromatic light) and electrical/electromagnetic stimulation. The various modalities of EMS energy differ from each other only in their wavelength or frequency, and often overlap with adjacent areas of the EMS.

Common Forms of Biophysical Agents

Category	Biophysical Agents
Electromagnetic Spectrum	Electrical stimulation (ES)
	Electromagnetic fields (EMF)
	Pulsed radio frequency energy (PRFE)
	Phototherapy: infrared (IR), ultraviolet (UV), light emitting diode (LED)
Acoustic	Low frequency ultrasound (LFU) KHz
	High frequency ultrasound (HFU) MHz
Mechanical/ Kinetic	Subatmospheric such as NPWT but also including suction
	Kinetic (whirlpool, pulsatile lavage, vibration)
	Atmospheric (hyperbaric and topical oxygen)


Electrical and magnetic fields are two component properties of electromagnetic radiation that travel perpendicular to each other and are always present together. Properties of these two fields may be altered by the device design so that one is dominant. *In vitro* studies by Aaron et al. (2004)¹ and Bassett (1987)² indicate that electrical stimulation (capacitive ES) and electromagnetic fields (EMF) induce similar physiological responses that are important for wound healing; however, there are sufficient distinctions between the two to categorize and evaluate them independently. Currently there is insufficient evidence to identify an optimal EMS frequency or wavelength signal for treating pressure ulcers.

Other forms of biophysical energy that have been studied in the management of pressure ulcers include acoustic, mechanical, and kinetic energy. Some delivery devices provide more than one form of biophysical energy. For example, megahertz (MHz) and kilohertz (kHz) ultrasound devices respectively transmit high and low frequency acoustic (sound) waves and kinetic energy (pressure waves); pulsed lavage delivers kinetic and mechanical energy and suction (a form of sub-atmospheric pressure). Whirlpool delivers thermal (infrared) and mechanical energy (agitation).

All of these biophysical energies should be delivered to the individual using medical devices that meet local technical and legal requirements as appropriate to the individual's health and wound condition. Use of biophysical agents should be directed by and under the supervision/management of an appropriately licensed health professional educated and trained in safe and effective selection, application, and monitoring methods.

The use of electrical stimulation for preventing pressure ulcers is reported in the guideline section *Emerging Therapies for Prevention of Pressure Ulcers*.

Electrical Stimulation

- 1. Consider the use of direct contact (capacitive) electrical stimulation to facilitate wound healing in recalcitrant Category/Stage II pressure ulcers as well as any Category/Stage III and IV pressure ulcers. (Strength of Evidence = A; Strength of Recommendation = )**

This recommendation is supported by six randomized controlled trials (RCTs), three of them being moderate quality studies published between 2009 and 2012.³⁻⁵ Franek et al. (2012)³ conducted a RCT investigating electrical stimulation (ES) compared with standard wound care (SWC) for treating lower extremity Category/Stage II to III pressure ulcers (n = 50). The mean baseline area of the pressure ulcers was 4.54 cm² and 3.97 cm² in the study and control groups respectively and the ulcers had persisted for 2 to 3 months duration. In the ES group (n = 26) participants received SWC, preventive care practices and high-voltage pulsed current (HVPC; monophasic, double-peaked impulses; 100 pps; 100 μs; 100 V; the intensity on sensory level, below the level of muscle contractions) applied for 50 minutes a day, five days a week. Cathodal stimulation applied for the first one to two weeks was replaced by anodal stimulation for the remainder of the treatment period. The SWC group received preventive care and SWC only. After six weeks, wound areas decreased significantly in both groups (p < 0.001 in both groups). Granulation tissue increased compared with baseline in both groups, but the difference was statistically significant only in the ES group (p = 0.0006). The mean decrease in surface wound area was 88.9% in the ES group and 44.4% in the control group (p < 0.001).³ The limitations of this study included a lack of blinding, and the SWC consisted of a variety of treatments that may not have been consistent between the groups (Level 2 study).

The results of a non-blinded RCT by Franek et al. (2011)⁴ also showed significant progress in the healing of Category/Stage I to III pressure ulcers in 29 participants treated with HVPC (monophasic, double-peaked impulses; 100 pps; 100 μs; 100 V; the intensity on sensory level, below the level of muscle contractions; 50 minutes a day; five days a week). The mean area and the mean duration of pressure ulcers were 4.45 cm² and 3.17 months respectively in ES group and 4.93 cm² and 2.80 months in the control group. All patients received topical wound treatment (local bath of potassium permanganate, compression of fibrolan, colistin and wet dressings containing 10% sodium chloride) and regular repositioning. After six weeks the mean surface wound area decreased significantly in both groups (p ≤ 0.001 in ES group; p = 0.002 in control group). In the ES group eight of 29 pressure ulcers closed versus four of 29 pressure ulcers in the control group. A mean decrease in surface wound area was 85.38% in the ES group versus 40.08% in the control group (p ≤ 0.001) (Level 2 study).

Another single-blind, parallel-group RCT was carried out by Houghton et al. (2010)⁵ with 34 participants with spinal cord injury (SCI) who had Category/Stage II to IV pressure ulcers. In the ES group (n = 16), HVPC (monophasic, double-peaked impulses; 50 μs; 50 to 150 V) with the stimulator device programmed to provide 20 minutes at a pulse frequency of 100 pps followed by 20 minutes at 10 pps and then 20 minutes off-cycle for eight hours each day, for a period of at least three months or until the ulcer closed. The polarity of the treatment electrode was initially negative and then alternated weekly. In a treatment period of 12 weeks, all Category/Stage II pressure ulcers closed in both the ES group and the control group. In the ES group, 33.3% of Category/Stage III to IV pressure ulcers closed compared with 7.1% in the control group (p = 0.550). In the ES group, 80% of pressure ulcers decreased in surface area by at least 50%. This result was significantly better than in the control group, where the mean wound area reduction was 36% (p = 0.02). The average percentage decrease in wound surface area at treatment end was significantly greater in the ES group compared with the control group (70.0% versus 36%; p = 0.048). A major achievement of this study was its finding that ES can be effectively delivered in the community or at home, without direct oversight by health professionals, with ES applied for approximately 5.3 hours per day, typically overnight. However, there was inconsistent application of the therapeutic ES protocol. In this study, SWC therapies were selected to meet the individual needs of participants, therefore management strategies varied. Specifically, the ES group received silver dressings to facilitate the ES therapy and none of the control group received silver dressings⁵ (Level 2 study).

Gardner et al. (1999)⁶ conducted a meta-analysis of studies investigating pressure ulcers and other wounds to quantify the effect of electrical stimulation on chronic wound healing. The pressure ulcers

were analyzed separately and are reported here. There were 216 pressure ulcers studied (130 treated with ES and 86 controls). The percentage of ulcer surface area reduction was 16.63% in the pressure ulcers treated with ES compared to 3.59% in the control groups. Two studies used in the meta-analysis included cross over designs^{7, 8} (Level 1 studies), where healing rates of pressure ulcers treated with electrical stimulation after the crossover mimicked the initial healing rates (12.9% per week). Pressure ulcers had the highest rate of healing with a net increase of 13.30% per week; a 403% increase over the control groups. The authors concluded there was more rapid healing in pressure ulcers treated with ES, although no conclusions could be drawn on which type of ES was more efficacious. Complete healing is seldom undertaken as an objective of biophysical agent clinical trials. In addition to reporting wound closure, other objective outcome measures usually reported are percent of healing per unit of time (e.g., week), and/or percent of ulcers healed. Several other studies on non-pressure ulcers or smaller samples have been done as well, but had methodological concerns.⁹⁻¹¹

A Cochrane Review from 2001 of three randomized controlled trials suggested a benefit associated with electrotherapy treatment for pressure ulcers, yet they cautioned that this recommendation was based on three small studies with a total of 140 patients.¹²

Electromagnetic Agents

1. **Consider the use of pulsed electromagnetic field (PEMF) treatment for recalcitrant Category/Stage II pressure ulcers as well as any Category/Stage III and IV pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = ⤵)**

Caution: No major adverse effects of electromagnetic therapy were reported in the research included in this review. Manufacturers of devices used to administer electromagnetic therapy do not recommend their use in individuals with pacemakers or other electrical implants, pregnancy or organ transplant. Caution is recommended for individuals with fever, active bleeding, seizures or dehydration.^{13, 14}

This recommendation is based primarily on expert opinion. Four RCTs conducted in the 1990s assessed this modality on chronic wounds and pressure ulcers¹⁵⁻¹⁷ (Level 2 studies). While the results were suggestive of safe and accelerated wound healing in Category/Stage II to IV pressure ulcers, methodological flaws were numerous.

A small double-blind RCT was conducted by Gupta et al. (2009)¹⁸ in 12 participants (mean age approximately 27 years) with a total of 24 Category/Stage III and IV pressure ulcers. The PEMF was administered to six participants (13 pressure ulcers) for 30 sessions over six weeks. There was a significant improvement in wound healing as assessed using the Bates-Jensen Wound Assessment Tool (BWAT); however, the control group receiving sham PEMF also achieved significant healing and there was no statistically significant difference between groups.¹⁸

A systematic review on the effectiveness of pressure ulcer treatments conducted by the Agency for Healthcare Research and Quality¹⁹ included the studies reported above and concluded that the evidence showed a trend toward improved rate of healing associated with electromagnetic therapy, but a lack of demonstrated clinical significance. The review suggested electromagnetic therapy could be considered as an adjunct to other interventions. Three different Cochrane reviews have been done on PEMF. The first in 2001²⁰ reviewed three small quantitative studies (all on venous ulcers) that were deemed to be weak, and the review concluded that no clear evidence was provided on the benefit of PEMF in chronic wound treatment. The second Cochrane review in 2006²¹ of two methodologically limited studies^{15, 16} with small samples concluded that the research did not provide evidence of benefit in using PEMF for pressure ulcer treatment and noted further research was needed. The third Cochrane review²² updated the search of Olyae Manesh et al. (2006)²¹ but found no new studies meeting the review inclusion criteria and made no changes to the conclusions.

Pulsed Radio Frequency Energy

Pulsed radio frequency energy (PRFE) has been shown to improve wound healing through promoting progression through inflammation to angiogenesis and tissue remodeling.²³ The radio frequency signal used (27.12 MHz) is non-ionizing and has a non-thermal effect.²⁴

1. **Consider the use of PRFE in the treatment of recalcitrant Category/Stage II pressure ulcers as well as any Category/Stage III and IV pressure ulcers (Strength of Evidence = C; Strength of Recommendation = ⊕)**

Caution: No major adverse effects of electrotherapy were reported in the research included in this review. Electrotherapy is contraindicated in individuals with electrical implants (e.g., pacemakers) or who are pregnant. Electrotherapy is contraindicated in local anatomical areas of the eye, testes and any malignancy. Electrotherapy should be used with caution in individuals with impaired circulation or devitalized tissue.²⁵

Two trials (Level 5 studies) assessed this modality on chronic wounds and pressure ulcers.^{24,26} While the results were suggestive of safe and accelerated wound healing in Category/Stage II to IV pressure ulcers, methodological flaws were present in these studies.

Phototherapy: Laser, Infrared and Ultraviolet

Phototherapeutic agents, as mentioned above, employ energy waves from the infrared (IR), visible and ultraviolet (UV) region of the electromagnetic spectrum. A development in phototherapy involves the use of clusters of laser diodes (LDs), light-emitting diodes (LEDs), super luminescent diodes (SLDs), or a mixture of these light sources (cluster probes). Laser energy differs from that of an LED or SLD because it is emitted in a more narrow beam (collimated), has a single wavelength (monochromatic) and its light waves are all in phase (coherent).²⁷ Combinations of these technologies are commonly used. The benefit of combining technologies include shorter treatment times, treatment of larger tissue areas, and biologic effects of different waveforms may be accessed.²⁷

Infrared Therapy

1. **Due to current insufficiency of evidence to support or refute the use of infrared therapy in the treatment of pressure ulcers, infrared therapy is not recommended for routine use at this time. (Strength of Evidence = C; Strength of Recommendation = ⊕)**

While studies and systematic reviews^{28,29} have been done on infrared therapy with and without heat; overall, findings are mixed. Studies were unclear regarding concurrent management strategies (e.g., the type of support surfaces used and what comprised standard wound care) and sample sizes were small.

Laser

1. **Due to current insufficiency of evidence to support or refute the use of laser therapy in the treatment of pressure ulcers, laser therapy is not recommended for routine use at this time. (Strength of Evidence = C; Strength of Recommendation = ⊕)**

Woodruff et al. (2004)³⁰ performed a meta-analysis of 24 animal and clinical studies on the effectiveness of laser (including infrared-based units) on wound healing in a variety of ulcers on both animals and humans. They concluded that laser therapy studies had numerous methodological limitations.

Ultraviolet Light Therapy

1. **Consider a short term application of ultraviolet C light (UVC) if traditional therapies fail. (Strength of Evidence = C; Strength of Recommendation = ⊕)**

This recommendation is based primarily on expert opinion. Currently, little evidence exists to support the use of ultraviolet light in the treatment of pressure ulcers. One study by Nussbaum et al. (1994)³¹ (Level 2 study) examined the effects of ultraviolet C light (UVC) in combination with ultrasound (n = 6) on pressure ulcer healing as compared to standard care therapy (n = 6) plus low level laser (n = 5) treatment in 17 participants with SCI. The combined UVC and ultrasound treatment enhanced healing over that attained with low level laser and standard care therapy. However, as the two treatment interventions (UVC and US) were combined, no definitive conclusion could be drawn as to their individual efficacy.

In a more recent study, Nussbaum et al. (2013)³² compared UVC therapy (n = 30) to placebo light therapy (n = 28) for healing Category/Stage II to IV pressure ulcers in individuals with SCI. In this larger study, there was no statistically significant difference in rate of complete pressure ulcer healing between the two groups (35% UVC group versus 60% placebo group, p = ns). Percent area change between consecutive weeks averaged 16.2% for the UVC group and 5.2% for placebo group (p = not significant [ns]). Although Category/Stage II pressure ulcers treated with UVC therapy showed significantly greater reduction in size from baseline compared to the placebo group at some weekly time points (p < 0.03 to p < 0.05), the study was not powered to measure this effect and the large participant drop out that was excluded from the analysis suggests these findings be considered with caution.

In an under-powered, double blinded study, Wills et al. (1983)³³ (Level 2 study) reported significantly shorter healing times (6.25 ± 0.55 weeks versus 8.38 ± 0.45 weeks) for superficial ulcers exposed to UV light (n = 8) when compared to a placebo treatment (n = 8; p < 0.02).

Small studies investigating the use of other light therapies including ultraviolet B light³⁴ and polarized light³⁵ have reported positive outcomes on pressure ulcer healing.

2. Consider a course of ultraviolet light as an adjunctive therapy to reduce bacterial burden in critically colonized Category/Stage III and IV pressure ulcers that have been debrided and cleansed. (Strength of Evidence = C; Strength of Recommendation = ⤵)

This recommendation is based primarily on expert opinion. A study by Thai et al. (2005)³⁶ demonstrated a reduction in bacterial numbers in 22 individuals with chronic wounds, only seven of which were pressure ulcers, exposed to 180 seconds of UVC (Level 3 study). *In vitro* and *in vivo* evidence also supports these findings^{37, 38} (Level 3 studies), as did a review.³⁹

At this time, there is insufficient evidence to make a definitive conclusion as to the benefit of phototherapy in reducing bacterial numbers in pressure ulcers. Until sufficient evidence exists, phototherapy may be considered an adjunctive therapy to reduce bacterial burden in critically colonized pressure ulcers. However, it should not be used in the absence of other therapies (See *Assessment and Treatment of Infection and Biofilm* section of this guideline).

Acoustic Energy (Ultrasound)

Ultrasound (US) is a mechanical vibration transmitted in a wave formation at frequencies beyond the upper limit of human hearing. Units of measure for US are called Hertz (Hz). One hertz = 1 cycle per second and 1kHz = 1000 cycles per second. This vibratory property affects the tissue cells. Different frequencies are used therapeutically to treat and assess soft tissues.

High frequency US used therapeutically, is delivered between 0.5 and 3 million cycles per second (0.5 to 3 MHz). Thermal and nonthermal properties, as well as cellular effects, are related to all frequencies.

Low frequency US is typically between 20 to 50 kHz. Applications of low frequency include fibrinolysis and debridement of slough. Wound debridement of slough uses 22.5, 25, 35 or 40 kHz depending on the design of the manufacturer.

1. **Due to current insufficiency of evidence to support or refute the use of noncontact low frequency (40 kHz) ultrasound spray (NC-LFUS) in the treatment of pressure ulcers, NC-LFUS is not recommended for routine use at this time. (Strength of Evidence = C; Strength of Recommendation \Rightarrow)**

Caution: No major adverse effects attributable to NC-LFUS were reported in the research included in this review. Noncontact low frequency ultrasound spray should not be used near prostheses, near electronic implanted devices (e.g., cardiac pacemakers), over the lower back or uterus in pregnant women; or over areas of malignancy; or on the face/head.⁴⁰

There is limited direct evidence on the efficacy of NC-LFUS in populations with pressure ulcers, although it is not infrequently used for wound care in geographic regions where it is available.

One uncontrolled study was conducted in participants ($n = 13$; $n = 11$ completed trial) with Category/Stage III pressure ulcers that had $>10^5$ bacterial count to determine bacterial reduction associated with NC-LFUS. The participants received a wound biopsy at baseline and at two weeks, after six treatments of NC-LFUS (mean duration of treatment was four minutes). The per-protocol analysis showed a reduction in mean bacterial burden after two weeks (2×10^7 versus 4×10^7 , $p =$ not reported). The study also reported a 26% reduction in mean wound area ($p =$ not reported) and a 20% reduction mean wound volume ($p =$ not reported). In the same study, the animal arm showed an overall slight decrease in total bacterial counts over 7 days, with increases in *S. aureus* and decreases in *P. aeruginosa* associated with NC-LFUS ($p =$ not reported) (Level 5 study).⁴¹

Evidence is emerging regarding the effect of NC-LFUS in treating suspected deep tissue injury (SDTI). A retrospective record review ($n = 85$ participants with 127 SDTIs) investigated the effect of NC-LFUS administered daily for five days then every other day (mean number of treatments = 10) compared with standard management. A non-validated assessment tool was applied retrospectively to photographs of wounds to assess total surface area, skin integrity and wound color/tissue. Scores for individual areas of assessment were combined to give a severity score from 3 to 18 (higher score indicates greater severity). The wound sizes were not comparable at baseline, with the control group having a larger mean total surface area ($p =$ not reported); however there was no difference on severity scale ($p < 0.913$). The NC-LFUS group achieved significant reduction in severity score at follow up compared to the control group ($t = 5.67$, $p < 0.000$); however the study was insufficiently powered. In the treated participants, 18% of SDTI spontaneously resolved, compared with 2% of participants who received no NC-LFUS (Level 4 study).⁴⁰

There is a range of indirect evidence on the efficacy of NCLFU in populations with other types of wounds.⁴²⁻⁴⁹ The highest quality indirect evidence comes from a double-blind RCT that included participants with diabetic foot ulcers that compared LFUS therapy (40 kHz) to sham therapy. The intention-to-treat analysis ($n=123$) showed no significant difference in healing rates (26% versus 22%, $p =$ ns). In the per protocol analysis ($n=55$), the LFUS group had a 40.7% closure rate compared with 14.3% for the control group ($p = 0.0366$); however, ulcers in the control group were of longer duration at baseline than those in the treatment group. Adverse effects included ulcer enlargement, blister, edema, erythema, pain and infection, but these did not occur at a significantly greater rate than for sham therapy (indirect evidence).⁵⁰

2. Consider use of low frequency (22.5, 25 or 35 kHz) ultrasound for debridement of necrotic soft tissue (not eschar). (Strength of Evidence = C; Strength of Recommendation = ⊕)
3. Consider use of high frequency (MHz) ultrasound as an adjunct for the treatment of infected pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = ⊕)

Caution: No major adverse effects of ultrasound were reported in the research included in this review. Its use is not recommended over anatomical areas with implanted materials or devices.

These recommendations are based on expert opinion. Limited evidence exists specific to the efficacy of HFUS or LFUS in the treatment of pressure ulcers. A 2006 Cochrane review⁵¹ identified three trials (n = 146 participants) with methodological limitations that reported on US to treat pressure ulcers, including the trial by McDiarmid et al. (1985)⁵² and the trial by Nussbaum et al. (1994)³¹ that included treatment with ultraviolet-C. None of the individual trials included in the Cochrane review found a significant effect for treatment with US. The meta-analysis also found no significant effect (risk ratio = 0.80, 95% CI 0.41 to 1.56, p = 0.51). An update to the review in 2009 did not include any additional studies. The Cochrane review concluded that there is no evidence supporting US in the treatment of pressure ulcers (Level 1 study).⁵¹

One of the studies reported in the Cochrane review was a low quality RCT conducted by McDiarmid et al. (1985)⁵² Forty participants with Category/Stage I and II pressure ulcers were randomized into a treatment and sham treatment non-thermal three MHz US study. Ulcers exposed to sound waves tended to heal more quickly but the difference was not statistically significant (p = 0.80). Ad-hoc analyses comparing effects in “clean” ulcers and in infected pressure ulcers suggested a significant effect in the healing of infected pressure ulcers, but the study was not powered to measure this effect and categorization of ulcers as clean or infected was based on visual appearance only (Level 2 study). A systematic review concluded that the above studies provided low strength evidence that the wound improvement observed with US is similar to that achieved with sham therapy.¹⁹

Until stronger evidence is available, traditional methods of treatment for infected pressure ulcers should be used and high frequency US can be considered as an adjunct.

Negative Pressure Wound Therapy

Negative pressure wound therapy (NPWT) has been in use as a wound treatment modality for decades, and while it did not originate for the treatment of pressure ulcers, there are data to support its use in pressure ulcer treatment. For the past decade, NPWT has been used as a late treatment for recalcitrant wounds. More recently, NPWT has been used as a first-line treatment for ulcers that could achieve benefit; however, more research is needed to identify which participants are most likely to benefit from this therapy.

Negative pressure wound therapy has its greatest efficacy in reducing wound volume,⁵³⁻⁵⁶ and can serve as an adjuvant therapy when combined with debridement and other treatments that promote healing, such as nutritional support and pressure redistribution. Today, most available NPWT wound contact layers are foam or gauze, and current research has increased our understanding of how the fillers interact with the wound. The research on NPWT has focused on the intermediate outcomes of ulcer healing: reduction in wound volume,^{54, 55, 57} wound bed preparation for skin grafting or flap closure,⁵³ ability to use a surface dressing rather than wound packing⁵³ and rate of healing.⁵⁸ Negative pressure wound therapy promotes wound healing through removal of third space edema,⁵⁹ thus enhancing nutrient and oxygen delivery;⁶⁰ removal of wound exudate, which is the medium for bacterial colonization;⁶¹ promotion of granulation tissue;⁶⁰ promotion of angiogenesis; and removal of wound inhibitory factors.⁶² Therefore, the intent of NPWT is to facilitate wound closure rather than to fully close or heal a pressure ulcer.

1. **Consider NPWT as an early adjuvant for the treatment of deep, Category/Stage III and IV pressure ulcers. (Strength of Evidence = B; Strength of Recommendation = 👍)**

Caution: Negative pressure wound therapy is not recommended in inadequately debrided, necrotic or malignant wounds; where vital organs are exposed; in wounds with no exudate; or in individuals with untreated coagulopathy, osteomyelitis or local or systemic clinical infection. Cautious use by an experienced health professional is recommended for individuals on anticoagulant therapy; in actively bleeding wounds; or where the wound is in close proximity to major blood vessels.⁶³

Negative pressure wound therapy has been shown to reduce the depth of pressure ulcers when compared to traditional forms of topical therapies.⁵³ A large retrospective review found that the rate of healing was significantly more rapid with NPWT (0.23 cm² per day). Healing rates were compared to those reported in a RCT by Ferrell et al. (1993)⁶⁴ in which the pressure ulcer healing rate in participants on low-air-loss beds or foam mattresses was reported at 0.090 cm² per day (for the participants on the low-air-loss bed). Joseph et al. (2000)⁵⁵ conducted a prospective randomized trial comparing NPWT to wet-to-moist gauze dressings covered with a thin film to simulate closed therapy without suction. Wound depth (percent change in depth) in this study was significantly more rapid ($p < 0.00001$) in the NPWT group (Level 2 study). Tissue biopsy showed more inflammation and fibrosis in the moist gauze dressing group and more granulation tissue in the NPWT group.⁵⁵

Wanner et al. (2003)⁵⁷ found no difference in time to reach a 50% decrease in ulcer volume in pelvic pressure ulcers in 22 individuals with SCI in order to allow surgical closure.

In one trial, de Laat et al. (2011)⁶⁵ investigated the reduction of wound volume using NPWT versus sodium hypochlorite dressings. One of the more notable findings to emerge from this research was a reduction in the median treatment time of 50% ($p = 0.001$). Wild et al. (2008)⁶⁶ also investigated reduction in wound area using NPWT versus Redon surgical drain bottles. The results of this research support the idea of using NPWT to improve healing outcomes for pressure ulcers. Findings showed an increase in surface granulation tissue of 54% in the NPWT and a reduction of granulation tissue in the Redon group ($p = 0.001$).

Wallin et al. (2011)⁶⁷ conducted a retrospective descriptive study in which data for 87 participants who had received NPWT for wound management was reviewed. The study identified that NPWT had a successful outcome for individuals with acute wounds rather than in those with pressure ulcers ($p = 0.001$). The results of an observational study by Ho et al. (2010)⁶⁸ did not find a significant statistical difference between the NPWT group and the non-NPWT group. In the NPWT group the non-healing subgroup had significantly lower serum albumin levels than the healing subgroup (2.9 ± 0.4 versus 3.3 ± 0.5 mg/dl, $p < 0.05$). Nutritional status appears to be important in the effectiveness on NPWT.

2. **Debride the pressure ulcer of necrotic tissue prior to the use of NPWT. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Negative pressure wound therapy is intended for use in pressure ulcers free of necrotic tissue. Therefore, NPWT therapy should begin after debridement.

3. **Follow a safe regimen in applying and removing the NPWT system. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Clean technique can be most used for NPWT dressing changes. As NPWT is commonly used in deep wounds, the health professional must be diligent in removing the entire previous tissue interface layer to prevent retained packing. One case study reported a retained foam dressing.⁶⁹ Fill the defect and dead space with dressing and record the number of dressings placed in the ulcer. Use caution to avoid placing wound interface dressings on intact skin. Clear film dressings should cover the wound interface dressing and a 3 to 5 cm border of intact periwound skin. Protect fragile periwound tissue with barrier films or dressings. Position the dressing tubing on flat body surfaces and away from the perineal areas, bony prominences, or pressure areas. Optimal negative pressure levels are not well-established, but usually range between 75 and 125 mm Hg. Place the drainage collection system on a level surface.

4. Evaluate the pressure ulcer with each dressing change. (Strength of Evidence = C; Strength of Recommendation = 👍)

The optimal dressing change interval is not well-established, and should be based on characteristics of the individual and the wound. Dressing change intervals can range from every 12 hours (wounds with heavy exudate) to twice weekly (wounds with light exudate), with the most common frequency being three times a week. If tissue ingrowth into the dressings or tubing is noted, lower pressures may be sufficient to correct this problem.⁷⁰ It is expected that granulation tissue will appear in the pressure ulcer; if present, monitor for tissue trauma or pain.

It is also expected that the ulcer will decrease in volume, and tunnels and undermining will resolve. If the ulcer appears clinically infected (e.g., erythema or purulence) or the individual presents with signs of infection (e.g., fever, malaise and/or leukocytosis), NPWT should not be reapplied. The individual and ulcer need to be fully evaluated with any deterioration (see the *Assessment of Pressure Ulcers and Monitoring of Healing* section of the guideline). If there is no change in ulcer dimensions (1 cm in any dimension) within two weeks, reassess for continuation of NPWT. If there is no exudate or the wound bed approaches skin level, consider discontinuation of the NPWT.

5. If pain is anticipated or reported consider:

- **placing a nonadherent interface dressing on the wound bed, underneath the foam;**
- **lowering the level of pressure, and/or changing type of pressure (continuous or intermittent); and/or**
- **using a moist gauze filler instead of foam. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Negative pressure wound therapy set on intermittent suction settings has been associated with clinical reports of pain. Lower levels of NPWT (75 to 80 mmHg) have been reported to reduce pain without compromising efficacy.⁷⁰ Nonadherent silicon mesh tissue interface dressings have been used effectively to reduce pain with dressing removal. The use of petrolatum or emulsion based dressings reduces efficacy of wound fluid transfer.

6. Educate the individual and his/her significant others about negative pressure wound therapy when used in the community setting. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Negative pressure wound therapy systems can be used in outpatient or home settings. Provide adequate education so that the individual and his/her significant others know what to do if the seal loosens; alarms ring; blood or tissue are seen in the tubing; or local erythema develops. Emergency contacts should be provided.

Hydrotherapy: Whirlpool and Pulsatile Lavage with and without Suction

Hydrotherapy uses water (with or without the use of additives) or saline to stimulate wound healing and to cleanse and debride wounds. Warm water (IR energy) provides superficial warming of tissue, and may have beneficial physiological effects of increasing vasodilation and perfusion, thus increasing oxygen delivery to aid in healing. The effectiveness of whirlpool or pulsatile lavage with and without suction on pressure ulcer healing is largely unknown.

Whirlpool

Whirlpool is seldom used and is no longer recommended. Whirlpool has become a generic name for a metal or plastic tub with an agitator/turbine attached or built into the tub that is of a suitable size to submerge a body part when filled with heated water. The water hydrates and softens the tissue. Vigorous rinsing of the wound and skin with potable warm water following immersion to remove bacteria and effluent from the water is required due to the risk of wound contamination.

1. **Whirlpool should not be considered for routine use in treating pressure ulcers due to the potential for contamination and the emergence of newer hydrotherapies. (Strength of Evidence = C; Strength of Recommendation = ⊕)**

Caution: Individuals with dependent lower extremity edema or peripheral vascular disease,⁷¹ immunocompromised individuals, those who are mechanically ventilated and lethargic, and incontinent individuals should never be immersed.

Whirlpool has been used in the past for wound cleansing and reducing bacterial bioburden. Due to the risk of exposure to pathogens and potential wound contamination, it is not recommended as a routine treatment for pressure ulcers. Newer hydrotherapies have replaced whirlpool as a recommended treatment option.

One randomized clinical trial (n = 42) provided evidence that whirlpool treatments plus moist wound dressings led to faster healing rates over moist wound dressings alone in surgically debrided, clean, granulating, Category/Stage III and IV pressure ulcers (0.39 cm/week compared to 0.17 cm/week for moist wound dressings alone)⁷² (Level 2 study). No adverse effects were reported. *In vitro*, adding chloramine-T at 200 ppm for 5 to 20 minutes was effective against three virulent gram-positive bacteria without fibroblast damage.⁷³

Pulsed Lavage with/ without Suction

When pulsed lavage is used, normal saline may be delivered between 4 and 15 psi (pressurized irrigation) through a mechanical apparatus. Suction (subatmospheric pressure) may be concomitantly employed to aspirate wound debris and remove microorganisms. The use of mechanical energy through a pressurized spray also assists with the removal of wound debris.

1. **Consider a course of pulsed lavage with suction for wound cleansing and debridement. (Strength of Evidence = C; Strength of Recommendation = ⊕)**

One double blind RCT (n = 28, n = 14 treated with lavage) provided moderate quality evidence that daily low pulsed lavage (with 1 liter normal saline at 11 psi applied over 10 to 20 minutes) was associated with faster healing rates for Category/stage II and IV pressure ulcers in patients with SCI compared with sham treatment. Although pressure ulcers treated with pulsed lavage showed significantly greater negative changes over time in depth, width, length and volume (all p < 0.0001), 95% confidence intervals (CI) spanned the null value⁷⁴ (Level 2 study).

Vibration Therapy

The use of vibration therapy to promote wound healing involves the application of mechanical vibration to part or all of the body. It is thought that this type of therapy stimulates blood flow due to mechanical stresses of endothelial cells resulting in vasodilation.⁷⁵

1. **Due to current insufficiency of evidence to support or refute the use of vibration therapy in the treatment of pressure ulcers, vibration therapy is not recommended for routine use at this time. (Strength of Evidence = C; Strength of Recommendation = ⊕)**

One non-blinded RCT (n = 31) provided evidence that the application of mechanical vibration led to improved healing rates of Category/Stage I pressure ulcers. This study identified that more pressure ulcers in the experimental group healed compared to the control group (40% versus 9.5% p = 0.033). The mean relative change per day of wound area was superior in the experimental group (20.4 ± 27.2% versus 6.4 ± 6.9%, p = 0.007). The researchers suggested that seasonal variations in microclimate may have influenced the findings⁷⁶ (Level 2 study).

Oxygen for the Treatment of Chronic Wounds

Hyperbaric Oxygen Therapy (HBOT)

1. **Due to current insufficiency of evidence to support or refute the use of hyperbaric oxygen therapy in the treatment of pressure ulcers, hyperbaric oxygen therapy is not recommended for routine use at this time. (Strength of Evidence = C; Strength of Recommendation = ⤴)**

Hyperbaric oxygen therapy (HBOT) is a therapy in which the individual breathes 100% oxygen at pressures greater than normal atmospheric (sea level) pressure or more than 1 atmosphere absolute (ATA). Pressures of up to three times normal atmospheric pressure (3 ATA) may be utilized.

The only study on HBOT for pressure ulcers was conducted by Rosenthal et al. (1971)⁷⁷ In this study, the HBOT treatment of 18 participants with 38 pressure ulcers was compared to treatment of three controls. Twenty-two pressure ulcers healed completely (58%) and five (13%) had a greater than 50% decrease in wound size. The three controls with six pressure ulcers had no wounds heal and no wounds decreased in size 50% or greater. No inferential statistics were completed and no demographics or wound sizes were compared between groups (Level 3 study).⁷⁷ Kranke et al. (2004)⁷⁸ conducted a Cochrane review of the effectiveness of HBOT in treating diabetic foot ulcers with osteomyelitis and reported that a pooled analysis concluded that diabetic wounds treated with HBOT were more likely to heal when compared to wounds treated with traditional therapy (indirect evidence).

Topical Oxygen Therapy

1. **Due to insufficient evidence to support or refute the use of topical oxygen in the treatment of pressure ulcers, topical oxygen is not recommended for routine use at this time. (Strength of Evidence = C; Strength of Recommendation = ⤴)**

Topical oxygen is a therapy in which 100% oxygen is applied directly to the wound. Pressures of 22 mm Hg and 50 mm Hg are most often reported in the literature. Heng et al. (2000)⁷⁹ reported on a descriptive study that the healing rate in 15 individuals with 24 chronic wounds treated with topical oxygen. Nineteen of the wounds were neuropathic, so a maximum of five wounds could have been pressure ulcers. At 12 weeks, 22 of the 24 wounds were healed. The outcomes for the pressure ulcers were not reported separately. In a small study, Edsberg et al. (2002)⁸⁰ also reported that there was no difference in healing in individuals with pressure ulcers treated with topical HBO compared to those treated with electrical stimulation and topical hyperbaric oxygen.

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SURGERY FOR PRESSURE ULCERS

Introduction

Category/Stage III and IV pressure ulcers are often difficult to heal using conventional wound healing techniques. When a pressure ulcer does not respond to traditional management strategies including debridement, infection management, and advanced wound dressings, in conjunction with pressure redistribution, surgical management (e.g., surgical sharp debridement with or without split skin graft or flap closure) may be considered. In some cases (e.g., suspected sepsis or osteomyelitis) surgical sharp debridement becomes an urgent necessity.

This section focuses on preoperative, intraoperative, and postoperative recommendations for surgical management of pressure ulcers. It does not address specific surgical techniques; those decisions are more appropriately made by an experienced surgeon who has an understanding of the unique needs of the individual requiring surgical management of a pressure ulcer. It is also important that the surgeon determines and communicates the potential for healing prior to undertaking surgical intervention.

Preoperative Recommendations

- 1. Obtain a surgical consultation for possible urgent drainage and/or debridement if the pressure ulcer has advancing cellulitis or is a suspected source of sepsis. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Pressure ulcers are a known cause of sepsis and death.¹⁻⁵ Abscessed or grossly infected pressure ulcers should be drained to treat sepsis from the ulcer or advancing cellulitis.

Stable, hard dry eschar should not be debrided when there is insufficient blood supply to support infection control or healing, unless infection is strongly suspected. In the presence of clinical signs of infection, dry, stable eschar requires assessment by a medical practitioner/vascular surgeon and possible urgent surgical sharp debridement. These signs include:

- erythema,
- tenderness,
- edema,
- purulence,
- fluctuance,
- crepitance, and/or
- malodor.

See the *Wound Care: Debridement* section of the guideline for further discussion.

- 2. Obtain a surgical consultation for possible surgical sharp debridement for individuals with undermining, tunneling/sinus tracts, and/or extensive necrotic tissue that cannot be easily removed by other debridement methods as appropriate to the individual's condition and goals of care. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This recommendation is supported by expert opinion from nine clinical practice guidelines.⁶⁻¹⁴

- 3. Obtain a surgical consultation for possible operative repair in individuals with Category/Stage III or IV pressure ulcers that are not closing with conservative treatment as appropriate to the individual's condition and goals of care, or for individuals who desire more rapid closure of the ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Category/Stage III and IV pressure ulcers are missing large amounts of soft tissue, including skin, subcutaneous fat and sometimes muscle. Exposed bone can also be present, making osteomyelitis highly

probable. These ulcers often require months to years to heal conservatively.¹⁵ Surgical excision and repair of the ulcer establishes durable, thick, soft tissue coverage and revascularizes the wound.

Although most individuals initially heal from surgery, recurrence of pressure ulcers in the long term is not uncommon. Recent case series studies have reported initial post-surgical wound dehiscence rates from 10 to 49%¹⁶⁻¹⁹ and long term (greater than 12 months) pressure ulcer recurrence rates ranging from 11.4% to 39%.¹⁷⁻²¹ In a multivariate analysis of the outcomes of 231 pressure ulcer flap surgeries (137 individuals) Keys et al. (2010)¹⁹ reported that 27% of cases healed without any complications and never recurred; 49% experienced some wound dehiscence; 16% of cases required early surgical revision due to dehiscence and 39% developed long term recurrence at the same site (Level 4 study).

The literature has reported some benefits of flap closure surgery. Srivastava et al. (2009)¹⁷ reported an 87% total healing rate after a mean follow up period of 15.4 ± 7.45 months for their case series of 39 pressure ulcers in 25 individuals with spinal cord injuries (SCI) or disorders. The authors reported that surgical repair of pressure ulcers was associated with significant improvements ($p =$ not reported) in functional ability as measured using the Barthel Index immediately post-operatively and at long term follow up (range 12 to 21 months) and in neurological evaluation assessed using American Spinal Injury Association (ASIA) grade (Level 5 study).

3.1. Evaluate the risk of surgery for the individual. (Strength of Evidence = C; Strength of Recommendation =)

General anesthesia is required for T-6 paraplegics and tetraplegics to control hyperreflexia and autonomic dysfunction. General anesthesia is also required when the individual is positioned prone for the operation. Operative procedures may last up to three hours and may result in blood loss requiring transfusion. Time spent undergoing surgery also places individuals at risk of new pressure ulcers, with longer surgical durations associated with a greater risk.²²⁻²⁴ Individuals with wounds who undergo surgery with general anesthetic are reported to have more comorbidities and greater risk than an average individual undergoing surgery.²⁵ Individuals with medical conditions that would be worsened by general anesthesia, blood loss, systemic stress, or immobility following surgery are usually not candidates for repair.

In a multivariate analysis of risks for post-operative complications in individuals undergoing surgical closure of a pressure ulcer, Thiessen et al. (2011)²⁶ reported a significant decrease in risk for individuals who had no pre-operative paralysis (odds ratio [OR] = 0.081, 95% confidence interval [CI] 0.009 to 0.706, $p=0.02$). There was also a lower risk of complications for individuals who were not hospitalized when their pressure ulcer developed (OR = 0.108, 95% CI 0.0021 to 0.563, $p=0.008$). There was no relationship between the type of flap closure performed and risk of post-operative complications (Level 3 study). In a small case series report of individuals in the Philippines undergoing surgical closure of a pressure ulcer ($n=16$), Estrella et al. (2010)²⁰ reported that more complications occurred in individuals in younger age groups (aged under 54 years, $p=0.039$), and there was no association between post-operative complications and presence of a co-morbidity ($p = 0.458$). However, this was a small study in which non-standard pressure management strategies were reported, therefore the findings cannot be generalized to other populations (Level 5 study).

Various tools are often used by surgeons, anesthesiologists and anesthesiologists to assist in an assessment of the individual's fitness to undergo surgery and general anesthetic, including the American Society of Anesthesiologists (ASA) classifications system, APACHE II and the Physiological and Operative Severity Score for enumeration of Mortality and Morbidity (POSSUM).²⁷ Kurita et al. (2009)²⁸ conducted an investigation to validate the use of POSSUM and O-POSSUM (a version of POSSUM adapted for use in orthopedic patients) as a predictor of mortality risk for individuals with pressure ulcer undergoing surgical sharp debridement, split skin grafts or flap closures. A cohort of individuals undergoing pressure ulcer surgery ($n=50$ individuals; $n = 71$ surgeries) was compared to a cohort of individuals undergoing surgery that was not related to chronic wounds ($n = 62$ individuals; $n = 62$ surgeries). The study found that participants

undergoing pressure ulcer related surgeries had higher predicted mortality scores than non-pressure ulcer participants on both the POSSUM and O-POSSUM ($p < 0.01$) and both scales were considered valid predictive methods. The results may have been influenced by the difference in mean age between the cohorts (72.1 ± 17.5 years in the pressure ulcer participants versus 47.2 ± 20.8 years in the non-pressure ulcer participants). The O-POSSUM was considered to have the best discriminatory power (area under curve [AUC] = 0.83 ± 0.08) (Level 4 study).

4. Confirm the individual's end-of-life preferences if anticipating surgery. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. The individual's and family's expectations of the operation and the ability of the individual to tolerate surgery and surgical recovery should be understood. Palliative care can include surgery for the treatment of pain and control of odor when the risk-benefit ratio is favorable.³ The guideline section *Special Populations: Individuals in Palliative Care* provides further details.

5. Evaluate and optimize factors that may influence surgical healing and long term recurrence prior to surgery. (Strength of evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. The fact that surgery is performed to promote pressure ulcer repair does not remove the risk for recurrence of pressure ulcers. Pressure ulcer recurrence rates reported in case series with greater than 12 months follow up ranged from 11.4% to 17.3%.^{17, 18, 20, 21} Conducting a pre-operative assessment of factors that may influence the individual's recovery and risk of recurrence enables identification and address of potential complications intra- and post-operatively.

5.1. Evaluate and promote the individual's ability to adhere to a postoperative management plan. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Willingness to adhere to an ongoing management plan for pressure relief and daily inspection of skin must be confirmed with the individual. Adequate preoperative education may contribute to concordance (see recommendation below).

5.2. Evaluate and optimize physical factors that may impair surgical wound healing. (Strength of Evidence = B; Strength of Recommendation = 👍👍)

In a retrospective multivariate logistic regression of data from 137 individuals (231 flap surgeries) over 15 years, having had previous flap surgery at the same site (OR = 3.84, 95% CI 1.23 to 11.94, $p = 0.02$), poor diabetes control (OR = 3.84, 95% CI 1.11 to 4.19, $p = 0.024$) and being aged less than 45 years at the time of surgery (OR = 4.89, 95% CI 1.19 to 20.08, $p = 0.028$) were significant predictors of impaired healing requiring further surgery¹⁹ (Level 4 study).

Nutritional status must be optimized, because the operative procedure will markedly enlarge the wound temporarily. Any nutrient deficiency should be corrected. Dietary supplementation or tube feeding may be indicated. Blood glucose levels should be optimized. Optimized high calorie, high protein diet in the pre-operative period was a helpful component in a number of surgical protocols^{20, 21} (Level 5 studies).

Infection of the pressure ulcer should be determined by tissue biopsy or quantitative swab technique and controlled with local debridement, non-toxic topical antiseptics, topical antibiotics and/or systemic antibiotics as per the recommendations of the treating physician. (also see recommendations in the *Assessment and Treatment of Infection and Biofilms* section of the guideline). Appropriate diagnosis and pre-operative infection management has been a helpful component of numerous surgical protocols (Level 3 study)²⁶ and (Level 5 studies).^{17, 21, 29}

Control of factors that may increase the risk of infection is also important. Diarrhea should be controlled to prevent fecal contamination of the wound. Control of diarrhea may require fecal containment systems; constipating agents or parenteral feeding. A diverting colostomy may

occasionally be necessary.^{30, 31} Individuals with SCI preparing for surgery could be encouraged to perform intermittent clean self-catheterization to prevent urinary contamination of sacral pressure ulcers²¹ (Level 5 study).

Spasms need to be controlled, because they can disrupt suture lines. All nicotine use must be stopped prior to surgery, with plans to continue nicotine cessation until the incision and wounds are well healed (for a minimum of 4 weeks afterward).³² Individuals taking cortisone, chemotherapy, antiproliferative, or immunosuppressive drugs may have a higher complication rate and a longer healing period. Reduction in dosages of these medications (if feasible) may help with wound healing.

5.3. Procure and maintain equipment for the prevention and treatment of pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Any high specification pressure redistribution support system (see *Support Surfaces* section of the guideline) planned for postoperative use should be procured prior to surgery. Optimally, the individual should be cared for on the high specification pressure redistribution support surface prior to surgery to determine tolerance of the bed (e.g., dyspnea and weightlessness). In one surgical protocol, participants awaiting pressure ulcer surgery were encouraged to use prone positioning on a pressure redistribution support system in the pre-operative period in preparation for the post-operative recovery period²¹ (Level 5 study). Appropriate seating support surfaces should also be organized prior to surgery (see the *Support Surfaces* section of the guideline).

Appropriate equipment in the individual's home setting or usual living environment is essential for long term recovery and reduction in risk of pressure ulcer reoccurrence. The individual's wheelchair, wheelchair cushion and other mechanical devices should be assessed prior to surgery. Assistance in attainment of appropriate equipment and education in its maintenance should be commenced prior to surgery. Further recommendations for specialty equipment in the home setting are discussed in the *Implementing the Guideline: Patient Consumers and Their Caregivers* section of the guideline.

5.4. Evaluate and optimize psychosocial factors that often impair surgical wound healing. (Strength of Evidence = B; Strength of Recommendation = 👍)

Family involvement can improve short and long term outcomes. Establishing a viable social network is crucial to recovery from surgery and maintaining a healed surgical site. Schryvers et al. (2000)³³ conducted a retrospective review of 20 years of practice and 168 individuals with pressure ulcers that required surgical repair. The study reported that the majority of participants were paraplegic, unemployed men who had a low level of education. Most lived alone or with family but were independent in self-care (Level 5 study). This suggests that the ability of the individual to return home safely should be ascertained prior to surgery. Kierney et al. (1998)³⁴ have achieved a very low 19% ulcer recurrence rate by combining plastic surgery with a collaborative, inter-disciplinary, post-operative management protocol that included a strong focus on education, rehabilitation and social support that extended beyond the individual's discharge from hospital (Level 5 study).

Yarkin et al. (2009)³⁵ investigated psychiatric state and quality of life for both paraplegic and tetraplegic individuals undergoing pressure ulcer reconstruction (n = 17) and their family caregivers (n = 18). Prior to surgery, the individuals with pressure ulcers had significantly lower scores (p < 0.05) on all components of the Short Form-36 (SF-36) compared with the national (US) average of the general population. Family caregivers had significantly lower scores for the SF-36 components of social function, emotional difficulty and mental health, but no significant difference for physical function, physical role difficulty, pain, general health or energy levels. This suggests that living with a chronic condition (such as SCI) and managing a pressure ulcer significantly impacts on the quality of life of individuals and their families, and supports may be required in the post-operative period. In the six month follow up after surgery, Yarkin et al.

(2009)³⁵ established significant improvements in SF-36, Beck Depression Inventory (BDI) and Trait Anxiety Inventory (TAI) scores for both individuals who underwent surgery and for their caregivers (all $p < 0.05$). The authors did not report on the use of psychosocial supports by study participants (Level 3 study).

- 6. Evaluate the individual for osteomyelitis if exposed bone is present, the bone feels rough or soft, or the ulcer has failed to heal with contemporary therapy. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Osteomyelitis has been reported in up to 32% of individuals with pressure ulcers.^{36, 37} Diagnostic assessments may include plain film X-rays, white blood cell counts, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), bone scans, magnetic resonance imaging (MRI), computer tomography (CT) scan, and/or biopsy, depending on the clinical situation.

Growing research has shown some benefits of using MRI for the diagnosis of osteomyelitis, although there is insufficient evidence on which to base definitive recommendations.³⁸⁻⁴⁰ A retrospective review of 41 MRI scans conducted on 37 individuals with pressure ulcers showed a significant association between an intermediate to high probability of osteomyelitis and both cortical bone erosion (Pearson's $r = 0.84$) and abnormal bone marrow edema (Pearson's $r = 0.82$). There was high interrater agreement ($\kappa = 0.92$, 95% CI 0.84 to 1.01, $p < 0.0001$) between radiographers on the likelihood of osteomyelitis³⁸⁻⁴⁰ (Level 5 study). However, it was determined in the analysis of a retrospective case-controlled study ($n = 65$) of individuals with osteomyelitis undergoing flap reconstruction that a diagnostic preoperative MRI scan did not significantly alter clinical or surgical management of the individual or clinical outcomes compared to diagnosis through bone cultures taken during the surgical procedure⁴¹ (Level 5 study).

- 6.1. Resect infected bone prior to or during surgical closure unless bone involvement is too extensive. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Permanent healing of the pressure ulcer or successful surgical closure are unlikely until osteomyelitis is controlled. Bacteria in bone have a profoundly detrimental effect on the viability of the flap. Marriott et al. (2008)⁴² reported on a retrospective review of 157 individuals with pressure ulcers from three cohorts: those with acute osteomyelitis, chronic osteomyelitis, or no osteomyelitis. The groups were compared for length of hospital stay, wound infection, wound breakdown requiring more surgery, and same-site ulcer recurrence. The cohort with acute osteomyelitis had longer hospital stays and greater incidence of wound breakdown and ulcer recurrence. The researchers recommended surgical debridement of chronic osteomyelitic bone (Level 5 study).


When bone involvement is too extensive for safe surgical removal, the infection should be treated appropriately with antibiotic therapy. Flap surgery should be timed appropriately with respect to antibiotic therapy.

Intraoperative Recommendations

During surgery, patients are immobile, positioned on a relatively hard surface, unable to feel the pain caused by pressure and shear forces, and are unable to change their position in order to relieve pressure. These factors increase the risk of pressure ulcer development in the intra-operative period. The section *Special Population: Individuals in the Operating Room* provides comprehensive guidelines for support surface selection and positioning (including in the prone position) in the operating room.


- 1. Excise the ulcer, including abnormal skin, granulation and necrotic tissue, sinus tracts, bursa and involved bone to the extent possible at surgical closure. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Healing rates were similar for single-stage or multiple-stage operations at 88% and 89%, respectively.⁴³ This finding was true regardless of patient age, the size of the ulcer, or the number of prior operations on the ulcer. Laing et al. (2010)⁴⁴ reported on individuals who underwent surgical debridement followed by closure using negative pressure wound therapy, approximately 50% of whom required definitive surgical reconstruction after a mean of 4.3 weeks. Following the surgical debridement, 12% of the individuals experienced bleeding and required transfusion, leading the researchers to propose that a multi-stage procedure may facilitate hemostasis and prevent hematoma formation. However, there was no comparative group and the results were based on a small sample size (n = 41) from one surgical facility (Level 5 study).

- 2. Design flaps with composite tissues to improve durability. When possible, choose a flap that will not violate adjacent flap territories to preserve all future options for flap coverage. (Strength of Evidence = C; Strength of Recommendation = )**

This statement is based on expert opinion. Arterialized flaps containing muscle and/or fascia (often with the overlying skin) restore the form, function, and blood supply of the missing tissues. The arterialized tissue replaces the physiologic barrier of the skin and improves vascular supply.⁴²

The most durable ulcer closure technique fills the defect with bulk to provide padding and protect underlying structures. There are many flaps that can be used for closure of pressure ulcers. Most of the literature on flaps for pressure ulcer repair contains reports of improvements in flap design for pressure ulcers. Reports of randomized clinical trials (RCTs) for operative repair of pressure ulcers are almost nonexistent in the literature.

- 3. Use a flap that is as large as possible, placing the suture line away from an area of direct pressure. Minimize tension on the incisions at the time of closure. Consider possible functional loss and rehabilitation needs, especially in ambulatory individuals. (Strength of Evidence = C; Strength of Recommendation = )**

There is increasing evidence that a variety of musculocutaneous and fasciocutaneous flaps can be used successfully to reconstruct pressure ulcers. Free flaps can also be used for reconstruction, especially in those individuals with large ulcers for which local flaps cannot cover the ulcer. Singh et al. (2013)²¹ reported good or excellent outcomes for 97% of individuals undergoing flap surgery where the type of flap was selected based on individual patient assessment (Level 5 study). There is minimal literature on direct surgical closure of pressure ulcers.

Lemaire et al. (2008)⁴⁵ retrospectively compared outcomes in pressure ulcers repaired with myocutaneous flaps to those repaired with free flaps. Success rates for stable ulcer coverage did not differ between groups; however, the mean follow up was only 21 months (Level 4 study). In their case series report (n = 78 individuals; n=93 pressure ulcer closures), Ahluwalia et al. (2009)²⁹ reported similar complication and recurrence rates for those repaired with myocutaneous, musculocutaneous or fasciocutaneous flaps (Level 5 study). Kim et al. (2013)⁴⁶ also found no difference in complications or recurrence rates between pressure ulcer repair with a conventional tensor fascia lata (n = 17) compared with a tensor fascia lata perforator-based island flap (n = 23); however, the mean follow up period was only 9.6 months (Level 4 study).

In a retrospective analysis of participants undergoing flap closure for trochanter pressure ulcers (n = 94), Thiessen et al. (2011)²⁶ compared outcomes between those who underwent fasciocutaneous and musculocutaneous flaps. There was no statistically significant difference in mean length of hospital stay for individuals receiving a fasciocutaneous flap (75.45 ± 52.2 days) and those with a musculocutaneous flaps (64.76 ± 75.5 days, p = 0.06). There was also no significant difference in the rate of complications, including wound dehiscence (47% vs. 44%, p=0.835), hematoma or seroma (22% vs. 27%, p=0.628) and flap necrosis (8% vs. 11%, p=0.735). Recurrence rate was also not significantly different (32% vs. 26%, p = 0.648) after a mean follow up period of 3.10 ± 1.8 years (Level 3 study).

4. Transfer the individual from the operating table with adequate assistance to avoid disruption of the flap. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Blood flow to the flap is provided through the pedicle feeding the flap. The vessels in the pedicle can be injured by shear forces and pressure; therefore, individuals should be placed on a pressure redistribution support surface immediately following surgery.

Immediately following surgery it is important to avoid manual handling techniques that involve moving individuals from one surface to another by pulling on the buttocks and hips. Instead, lift the individual from the operating room table onto the bed rather than sliding or pulling.

Postoperative Recommendations

1. Select a high specification support surface that provides enhanced pressure redistribution, shear reduction, and microclimate control for individuals with who have undergone pressure ulcer surgery. (Strength of Evidence = B; Strength of Recommendation = 👍)

The various types of high specification support surfaces are discussed in detail in the *Support Surfaces* section of the guideline.

Individuals who have undergone surgical closure of a pressure ulcer are at higher risk for developing additional pressure ulcers. Their reduced mobility and limited positioning options following surgery increase risk of new pressure ulcers. The support surface should be appropriate for preventing new pressure ulcers, as well as able to distribute pressure away from the operative site, reduce shear and limit tension on the incision to prevent flap necrosis or delayed healing.

Air fluidized beds have been commonly used for pressure redistribution and shear reduction after surgical repair. Early research has shown better healing outcomes on beds with air fluidized features; however, this research was conducted in Category/Stage III and IV pressure ulcers healing without surgery. Munro et al. (1989)⁴⁷ reported superior healing rates with an air fluidized bed compared to a bed with a standard mattress (Level 2 study). Allman et al. (1987)⁴⁸ found an air fluidized support surface promoted faster healing than an alternating air surface covered by a foam pad (Level 1 study). Randomized controlled trials have demonstrated superiority of an air fluidized bed compared to a non-air fluidized support surface for healing pressure ulcers in non-surgical populations^{49, 50} (Level 1 studies).

Low-air-loss beds are also commonly used for the post-surgical individual. Ferrell et al. (1993)⁵¹ reported on improved Category/Stage III and IV pressure ulcer healing rates on low-air-loss integrated beds compared to 10 cm foam mattresses (Level 1 study). A pilot study compared healing after flap repair of pressure ulcers between an air fluidized surface (Clinitron®, Hill-Rom Inc.) and an alternating air mattress with modifications (NIMBUS® 3 Professional, Huntleigh Healthcare LLC).⁵² The alternating air mattress was modified to permanently deflate single mattress cells beneath the surgical site and the alternating pressure function was not used on the flap site. Pressure redistribution in use at the surgical site is unknown. No data were provided on any methods used to keep the participants aligned with the deflated portion of the bed or on any skin integrity problems at the junction of deflated and inflated/alternating cells. The study followed 40 participants for one week during an acute care stay after flap reconstruction of pelvic pressure ulcers. Individuals were randomly assigned to an air-fluidized bed (n = 15) or modified alternating-air bed (n = 18). There was no significant difference between the groups, with 13 participants in each group discharged from acute care with intact incisions. The small sample size and lack of follow up through to complete surgical site healing are shortcomings of this study (Level 2 study).

1.1. Avoid transferring the post-surgical individual onto a non-high specification support surface unless clinically indicated. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based on expert opinion. The risks and benefits must be evaluated. If the individual is placed on hard surfaces such as gurneys, stretchers, and x-ray tables in the early

postoperative period there is a serious risk of flap disruption or necrosis from increased pressure and shear. Any transfer from the high specification pressure redistribution support surface should be carefully managed to prevent injury during transfer. Time spent on surfaces that lack adequate pressure redistribution characteristics should be avoided or severely limited.

2. Avoid pressure, shear and friction in order to protect the blood supply to the flap. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Flaps rely on the blood supply in the tissues that is carried along with the tissues. Some flaps have deep blood vessels supplying the overlying tissue (e.g., gluteal flaps) and in others the blood flow is more superficial (e.g., latissimus dorsi flaps). This blood supply, classically called the 'pedicle' of the flap, can be damaged by pulling on the skin or applying pressure to the skin. It is important to know where the blood supply is coming from and how close to the surface the blood supply is located. The circulation to parts of the flap distal from the pedicle can also be compromised by pressure and shear. This should also be anticipated and managed by the treating physician.

Expert opinion on the use of bedpans for individuals with new pelvic flaps varies. They should be used with extreme caution, as they create pressure on the pelvic flap.

2.1. Assess the associated benefits and risks before elevating the head of the bed. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Elevating the head of the bed can have unintended consequences on flap healing and shear and should only be undertaken with a full understanding of the associated risks and benefits. Many hospitals have initiated evidence based protocols to limit aspiration pneumonia and ventilator-associated pneumonia by elevating the head of the bed for individuals confined to bed. Elevating the head of the bed increases tension on the incision from hip flexion, and increases interface pressure and shear, all of which place the individual at a serious risk of flap disruption or necrosis. It is important to understand the immediate and long term consequences of both options prior to applying a patient specific intervention.

2.2. Reposition the individual using proper manual handling technique and equipment. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Ongoing repositioning is important to prevent development of new or recurring pressure ulcers. Use of proper manual handling techniques and equipment (e.g., turning sheet, adequate turning team) will limit the need to drag the individual and reduce risk of disrupting the flap from shear and friction. Tension on the suture lines must be avoided when turning the individual in bed. Holding the individual's legs and back is preferred to pulling on the hips and buttocks. Further recommendations are provided in the guideline section *Repositioning and Early Mobilization*.

2.3. Dress the individual in appropriate clothing to prevent injury to the flap when using slide boards. (Strength of Evidence = C; Strength of Recommendation = 👍)

Hospital gowns that are open in the back permit the skin of the thighs and buttocks to drag on transfer devices or slide boards (i.e., for transfer into wheelchairs). Individuals should be adequately clothed to protect the skin during transfers. Clothing with zippers, buttons, or snaps should not be used over the surgical site or pressure points.

3. Regularly monitor wound drainage systems. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Drainage systems are placed to remove fluid from dead space and to prevent seroma and hematoma formation in the surgical site. Suction drains also help the flap adhere to the underlying wound bed.

Collections of blood and serum can become a source of infection and fluid accumulations can also place tension on the wound. Drain tubes should be regularly checked for kinking/clogging or other sources of occlusion. Drainage from wounds should be recorded, and those records should guide decisions for drain removal.

Drain tubes can also be a source of pressure and shear forces that increase the risk of new pressure ulcers. The guideline section *Medical Device Related Pressure Ulcers* provides comprehensive guidance on reducing the risk of pressure ulcers associated with drain tubes and other medical devices.

4. Report signs of flap failure to the surgeon immediately, including:

- pallor,
- mottling,
- incision separation,
- Increased drainage from the incision,
- edema, and
- bluish-purple tissue. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Flap failure can occur due to loss of arterial blood supply or impairment of venous return. Arterial inflow appears as pallor or mottling in the flap. Venous engorgement is fairly rare (except in free flaps) and presents as a swollen or bluish-purple tissue.

Black (1996)⁵³ suggested that when monitoring devices are not used for flaps, making rounds at the bedside is helpful in establishing a baseline for reference in later assessments. Singh et al. (2013)²¹ included routine daily inspection of the flap by the surgeon, caregiver and the patient in their management protocol (Level 5 study).

Suture line dehiscence is the most common complication after pressure ulcer surgery. In a 17-year review of the surgical treatment of Category/Stage III and IV pelvic area pressure ulcers in individuals with SCI the outcomes for 421 surgical procedures were reported. Suture line dehiscence occurred in 130 (31%) of the surgeries, with 45 (11%) requiring reconstruction and eight (2%) requiring skin grafting to heal³³. Foster et al. (1997)⁵⁴ reported on 114 patients with reconstructed flaps. Suture-line dehiscence occurred after 42% of their ischial reconstructions, 20% of their sacral reconstructions, and 15% of their trochanteric reconstructions. In a 5-year, retrospective study that included 101 participants with 179 pressure ulcers, Larson et al. (2012)¹⁸ reported suture line dehiscence in 15% of pressure ulcers. In smaller case series reports, researchers reported suture line dehiscence rates of around 10%^{16, 17} (all Level 5 studies).

5. Prevent hazards of immobility. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

The hazards of immobility on every body system are well known. Usual postoperative interventions for pulmonary hygiene and to prevent blood stasis are important. Individuals on pressure redistribution surfaces still require repositioning and skin inspection for new pressure ulcers. Indwelling urinary catheters are used to prevent exposure of the incision line to urine. Range-of-motion exercises of the arms can begin, but flexion of the hips should be avoided until approved by the surgeon.


6. Initiate a program of progressive sitting according to the surgeon's orders. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

When weight bearing on the operative site is allowed, it should be graduated and progressive^{17, 20, 21, 29}. Sitting should increase in duration if no erythema is noted over weight bearing areas. Skin tolerance to pressure over the wound site should be assessed after each period of sitting. If healing is slow or other confounding factors exist (e.g., obesity, multiple ulcers, or high level of paralysis) then weight bearing may be delayed until incisions are completely healed.

6.1. Position the individual on a pressure redistributing support surface when sitting out of bed. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Individuals who have undergone pressure ulcer surgery have significant reduction in mobility and are at an increased risk of new pressure ulcers, as well as risk of flap necrosis and recurrence of pressure ulcer at the surgical site. Randomized controlled trials conducted in participants at high risk of pressure ulcers (but not post-surgery) that provide evidence for the use of pressure redistribution cushions for reducing the risk of pressure ulcers are reported in the *Support Surfaces* section of the guideline^{55, 56} (Level 2 studies).

The *Support Surfaces* section of the guideline includes comprehensive recommendations on the selection of seating support surfaces that are constructed in order to redistribute pressure away from existing pressure ulcers and reduce interface pressure to prevent the development of new pressure ulcers.

7. Confirm the presence of healthy lifestyle choices and a supportive social network prior to discharging the individual from a facility. (Strength of Evidence = B; Strength of Recommendation = )

Yarkin et al. (2009)³⁵ conducted a prospective observational study (n = 18) investigating the psychosocial impact of pressure ulcer surgery for individuals with SCI. As discussed under Pre-operative Recommendations (see above), undergoing surgery for pressure ulcer repair was significantly associated with improvements in measures of depression, anxiety and social function. However, even with significant improvements associated with undergoing surgery, six months post-operatively the individuals with pressure ulcers maintained significantly poorer mean scores than the national US average for physical function, pain, general health, energy, social function, mental health and emotional role difficulty (p < 0.05 for all). Post-operatively, family caregivers had lower mean scores than the national US average for social function and mental health (both p < 0.05), although they did show significant improvements from pre-operative scores. A positive correlation was found for pressure ulcer recurrence between both pre-operative and post-operative depression measured on the BDI (p < 0.05 for both). Additionally, family caregiver anxiety measured on the TAI was significantly related to pressure ulcer recurrence (p < 0.05). The study highlights the importance of psychosocial well-being for both the individual and his or her caregivers in preventing pressure ulcer recurrence (Level 3 study).

Krause et al. (2004)⁵⁷ examined the factors associated with pressure ulcer recurrence in 633 individuals with SCI. The odds of having a recurrent pressure ulcer were positively associated with the number of years since injury (odds ratio 1.03 for every year since injury). Several protective behaviors were significantly associated with non-recurrent pressure ulcers. These included:

- leading a healthy lifestyle,
- being employed,
- eating a healthy diet,
- self-reported fitness, and
- exercise appropriate for level of injury.

In contrast, none of the three specific behaviors taught to prevent pressure ulcers were protective against recurrent pressure ulcers. Only two risk behaviors were identified for recurrent pressure ulcer history, including the number of cigarettes smoked. Of the four items related to prescription medication use, only use of medication for sleep was significantly related to pressure ulcer history. Several psychological proxy variables were significantly associated with recurrent pressure ulcers. A diagnosis of clinically significant depression was a significant risk factor for recurrent pressure ulcers. Of the locus of control scales, high internality scores were protective for recurrent pressure ulcers (Level 5 study).

Guihan et al. (2008)⁵⁸ reported that in a study of veterans with SCI, the strongest predictor of recurrent pressure ulcers was being African-American (odds ratio = 9.3). Additional predictors in this study included higher scores on the Charlson Co-Morbidity Index (indicating a higher burden of illness), the Salzburg Pressure Ulcer Risk Assessment Scales, and longer sitting time at discharge.

The *Implementing the Guideline: Patient Consumers and Their Caregivers* section of the guideline includes comprehensive recommendations for individuals regarding lifestyle and psychosocial aspects of living with and preventing pressure ulcers.

8. Provide or facilitate access to pressure ulcer prevention education for the individual and his or her caregivers prior to discharge from the facility. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Rintala et al. (2008)⁵⁹ compared three education delivery models for SCI veterans who had undergone flap surgery. One group (n = 18) received an enhanced education program with monthly structured follow-up contact (25 minutes phone call that included skin assessment, education and counseling) for two years following discharge. The second group (n = 10) received a standard education program and brief monthly telephone contact for skin assessment for two years following discharge. The control group (n = 10) received the standard education program and 3-monthly mail contact over the follow up period. In this study, the enhanced education program included up to four hours more one-on-one education delivery than the standard education program covering etiology, preventive strategies and equipment and including caregiver education. At two year follow up, significantly fewer participants in the enhanced education program group had a recurrence of pressure ulcers (33% versus 60% versus 90%, p = 0.007). For participants who received enhanced education, the OR of experiencing a pressure ulcer by 24 months was 0.228 (95% CI 0.08 to 0.647, p = 0.003). The groups were not equivalent at baseline, with a significant difference in the type of flap surgery performed, and the first two groups participated in another study concurrently, which may have provided additional reinforcement for preventive behavior (Level 2 study).

The *Implementing the Guideline: Patient Consumers and Their Caregivers* section of the guideline includes comprehensive recommendations for individuals on self-empowerment and knowledge acquisition.

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SPECIAL POPULATIONS

BARIATRIC (OBESE) INDIVIDUALS

Introduction

Obesity has increased dramatically in the last few decades.¹ Currently 65% of the global population live in countries in which being overweight or obese is associated with greater mortality than being underweight.² The World Health Organization (WHO) defines overweight and obesity as abnormal or excessive fat accumulation that may impair health.²

Obesity is associated with various skin and tissue health problems and diseases;³ however, precise causal relationships between obesity and pressure ulcer development are unclear. Based on finite element modeling,⁴ epidemiological data,⁵ and clinical experience, there appears to be a U-shaped relationship between body mass index (BMI) and pressure ulcer occurrence. Both very thin individuals and overweight-to-obese individuals are at higher pressure ulcer risk compared to individuals within a normal BMI range. However, while the association between underweight and increased pressure ulcer risk is established, evidence supporting the relationship with obesity seems to be less clear.

Epidemiological studies have demonstrated strong, weak or no relationship between obesity and pressure ulcers.⁶⁻⁸ Compher et al. (2007)⁹ conducted a secondary analysis of a cohort study (n = 3214) on risk factors for pressure ulcers and found a reduced odds ratio (OR) for pressure ulcers in obese individuals (adjusted OR = 0.70, 95% confidence interval [CI] 0.40 to 1.0), indicating that obesity might be a protective factor. Possible explanations for these findings are that non-comparable skin areas, non-comparable pressure ulcer Categories/Stages, and use of different BMI cut-offs and categories.

A particular feature of severe obesity is maceration, inflammation, and tissue/skin necrosis, especially in large and deep skin folds. Both an increased tissue weight that exerts additional load on dependent tissues and causes vascular occlusion, and a fragile vascular and lymphatic framework, is responsible for skin and tissue complications.^{3, 10}

Pressure ulcer prevention and treatment for the bariatric individual is similar to that for non-bariatric individuals; however, bariatric care is more challenging for a number of reasons.¹¹ The bariatric individual has increased difficulty moving either independently or with assistance. The increased body weight makes it difficult to view bony prominences and to redistribute pressure. Shear and friction are often increased as the bariatric individual is inclined to drag his or her heels and sacrum when getting out of bed. The increased pressure on the bowel and bladder from abdominal weight increases the risk of stress incontinence and diaphoresis, which increases the risk of skin maceration. Obesity can also compromise respiration due to impaired diaphragmatic movement and subsequent impaired tissue perfusion.

The recommendations below highlight important considerations in the care of bariatric individuals and should be considered in conjunction with the recommendations in the main sections of this guideline.

Recommendations for the Organization

- 1. Provide safe, respectful care and avoid injuries to both the individual and health professionals. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
- 2. Maximize workplace safety by implementing organization-wide bariatric management strategies that address manual handling techniques. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Health professionals involved in manual handling require appropriate training to avoid injury to both themselves and the individual during repositioning and transfer. Health professionals should be provided with education and training in the correct and safe use of equipment.

3. Provide pressure redistribution support surfaces and equipment appropriate to the size and weight of the individual. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Appropriate bariatric equipment is critical in maintaining or re-establishing mobility for bariatric individuals to address the primary risk factor for pressure ulcer development (i.e., immobility). Evaluate the safe working load, width and capacity of the equipment (e.g., beds, chairs, toilets, bed pans, mattress, wheel chairs, walkers, scales and lifts) to ensure it meets the needs of the individual and the care environment. Procure an appropriate range of bariatric equipment.

Assessing the Bariatric Individual

1. Calculate BMI and classify obesity. (Strength of Evidence = C; Strength of Recommendation = 👍)

Three classifications of overweight severity are identified:²

- obese I: BMI 30.0 to 34.9 kg/m²
- obese II: BMI of 35.0 to 39.9 kg/m²
- obese III: BMI ≥ 40.0 kg/m².

Body mass index, an index of an individual's weight in relationship to height, is calculated as:

$$\frac{\text{weight (kg)}}{[\text{height (m)}]^2} \quad \text{or} \quad \frac{\text{weight (lb)}}{[\text{height (in)}]^2} \times 703$$

To obtain an accurate standing height the individual should be measured without shoes and standing erect with the measuring scale placed flat on the head. Reclining heights can be taken when the individual is lying flat with one arm extended straight out in a 90° angle to the torso. A tape measure is used to measure from the middle of the sternum to the tip of the middle finger. The obtained measurement is doubled and documented as an approximate height.¹² Weigh an individual on a calibrated scale at the same time of the day, in light clothing, without shoes, after voiding, and without a catheter bag. Prosthetic devices should be removed prior to weighing, or weigh the devices and subtract the weight from the total weight.

While BMI is the same for all ages and both sexes amongst adults, it does have limitations. Very muscular individuals may fall into the overweight category when they are actually healthy and physically fit. The frail, elderly individual may fit into a normal range when in reality they have lost muscle mass.

Computing percentage of body fat using skinfold thickness measurements with calipers is more precise and is an inexpensive method. Other methods used to measure body fat include underwater weighing, bioelectrical impedance, dual-energy x-ray absorptiometry (DXA), and isotope dilution. However, these methods are expensive and require trained personnel and special equipment. Despite the limitations, BMI is the most common method used to classify obesity.

2. Assess all skin folds regularly. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

2.1. Assess adequate assistance to fully inspect all skin surfaces and folds. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

An assessment should be conducted on admission and regularly thereafter. Pay particular attention to skin folds in the following areas:

- behind the neck,
- mid back region,
- under the arms and breasts,
- under the abdomen or pannus,
- upper and lower thighs,
- perineal, buttock and sacral area, and
- calves, heels and ankles.

Pressure ulcers develop over bony prominences, but may also result from tissue pressure across the buttocks and other areas of high adipose tissue concentration. Pressure ulcers may develop in unique locations, such as underneath folds of skin and in locations where tubes and other devices have been compressed between skin folds. The combination of moisture trapped under skin folds, pressure of skin folds on the underlying skin, and friction and shear between the skin surfaces are all factors that contribute to pressure ulcer formation underneath folds of skin.

The weight of the pannus (the abdominal fat and the skin fold apron) can cause pressure ulcers to develop in areas such as the hip, pubis, thighs, trunk and torso.¹³ Assessing these areas should be part of the ongoing skin assessment for the bariatric individual.

Check skin for signs of maceration, which is a common occurrence for the bariatric individual due to increased diaphoresis. Check for damage to the skin from the impact and force of excessive friction and shear.

2.2. Differentiate intertriginous dermatitis from Category/Stage I and II pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)

Obese individuals are at higher risk for intertriginous dermatitis because their multiple skin folds form ideal conditions for inflammation and maceration. It is important to differentiate intertrigo from Category/Stage I and II pressure ulcers based on etiology and skin appearance. In the obese individual, the most common areas in which intertrigo develops include under the pannus, the breasts, and in the groin or perineum.^{13, 14}

3. Refer bariatric individuals to a registered dietitian or an interprofessional nutrition team for a comprehensive nutrition assessment and weight management plan. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

All bariatric individuals are at nutritional risk. The bariatric individual can be malnourished despite the appearance of being well fed. Under the direction of the interprofessional nutrition team, balance weight loss with providing adequate nutrients to prevent pressure ulcers in at risk bariatric individuals and to support healing in those with existing ulcers.

Bed Selection

1. Ensure the individual is provided with a bed of appropriate size and weight capacity specifications. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

1.1. Use beds that adequately support the weight of the individual. (Strength of Evidence = C; Strength of Recommendation = 👍)

Bariatric individuals may exceed the weight and width capacity of standard pressure redistribution support surfaces and require appropriate equipment designed to accommodate their increased girth and weight.

1.2. Check routinely for ‘bottoming out’ of the support surface. (Strength of Evidence = C; Strength of Recommendation = 👍)

The bariatric individual may cause the mattress to sink or ‘bottom out’.

1.3. Ensure that the bed surface area is sufficiently wide to allow turning of the individual without contact with the side rails of the bed. (Strength of Evidence = C; Strength of Recommendation = 👍)

Standard beds are 32 to 36 inches (81 to 91 cm) in width. Individuals who fill the width of the bed may be restricted in their ability to turn side-to-side or into positions that offload the sacral area.

2. **Consider selecting a support surface with enhanced pressure redistribution, shear reduction and microclimate control for bariatric individuals. (Strength of Evidence = C; Strength of Recommendation = 👍)**

The bariatric individual often experiences increased shear and friction with movement, and increased difficulty in redistributing pressure. The bariatric individual is also at increased risk of stress incontinence and diaphoresis. A support surface that optimizes pressure redistribution and microclimate control is required.

In a small observational study (n = 21), Pemberton et al. (2009)¹⁵ provided a low-air loss, continuous lateral rotation bed with advanced microclimate technology to bariatric individuals (BMI > 35 kg/m², mean BMI was 51.4 ± 10.3 kg/m²) with pressure ulcers. The individuals spent an average of 4.8 ± 2.5 days (range two to eight days) on the specialized support surface. Over the study period no new pressure ulcers developed, and existing pressure ulcers decreased from an average size of 5.2 ± 2.6 cm² to an average size of 2.6 ± 5.0 cm² (p = not reported). Mean participant comfort rating for the surface was 3.9 out of 4 (Level 5 study).

The *Support Surfaces* section of the guideline has further information on support surface features.

Equipment Selection

1. **Use wheelchairs and chairs that are wide and strong enough to accommodate the individual's girth and weight. (Strength of Evidence = C; Strength of Recommendation = 👍)**

- 1.1. **Use a pressure redistribution cushion designed for the bariatric individual on seated surfaces. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Biomechanical modeling studies suggest an increased risk of suspected deep tissue injury in the seated bariatric individual. In a biomechanical modeling investigation, Elsner et al. (2008)¹⁶ used finite element models to demonstrate that a higher BMI is associated with an increase in internal muscle tissue load under the ischial tuberosities. Sopher et al. (2010)⁴ continued this investigation using finite element models representing the same individual modeled with BMIs ranging from less than 16.5 kg/m² up to 40 kg/m². The study results showed that the percentage volume of muscle tissue under the ischial tuberosities increased over five times as BMI increased from 19 kg/m² to 40 kg/m². In a study by Elsner et al. (2008)¹⁶ increases on internal muscle load were of a greater magnitude in modeling of sitting on a hard surface compared with a soft chair (indirect evidence).

- 1.2. **Check routinely for 'bottoming out' of the cushion. (Strength of Evidence = C; Strength of Recommendation = 👍)**

The *Support Surfaces* section of the guideline has further information on support surface features.

2. **Where appropriate, provide bariatric walkers, overhead trapezes on beds, and other devices to support continued mobility and independence. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Repositioning

1. **Avoid pressure on skin from tubes, other medical devices and foreign objects. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
2. **Use pillows or other positioning devices to offload the pannus or other large skin folds and prevent skin-on-skin pressure. (Strength of Evidence = C; Strength of Recommendation = 👍)**
3. **Check the bed for foreign objects. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Foreign objects, including phones, remote controls, and eating utensils, may become lodged under the individual. These objects cause local loads and tissue deformation that contribute to skin breaking down to pressure ulcers.

Pressure Ulcer Care

- 1. Provide adequate nutrition to support healing. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Bariatric individuals, despite their size, may lack adequate nutrients to support healing of pressure ulcers. Goals of weight loss may need to be postponed or modified to ensure that adequate nutrients are provided for healing (see *Nutrition for Prevention and Treatment of Pressure Ulcers* section).

- 2. Assess pressure ulcers carefully for signs of infection and delays in healing. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Infection and delayed healing are more common in bariatric individuals. The *Assessment and Treatment of Infection and Biofilms* section of the guideline provides comprehensive recommendations on managing wound infection.

- 3. Monitor wound dressing materials closely, especially in large cavity wounds. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Additional skin folds and deeper tissue layers can impede assessment of cavity wounds and increase the risk of retained wound dressing materials. Fill cavity wounds with dressing materials carefully to reduce the risk of losing dressings in the wound. Document the number of dressings used to fill large wounds, and ensure that all dressings are removed at the next dressing change. The *Wound Dressings* section of the guideline provides further guidance on selection and use of wound dressings.

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CRITICALLY ILL INDIVIDUALS


Introduction

Critically ill people, cared for in intensive care units (ICUs), are a unique subset of hospitalized individuals and represent the sickest patients in the health care system. The development of a pressure ulcer presents an additional comorbid threat for an already severely compromised person. Pressure ulcer rates in the critical care population, are reported as the highest among hospitalized individuals.¹⁻³ This is attributed to the high level of disease/illness burden; hemodynamic instability, poor tissue perfusion and oxygenation requiring the use of vasoactive medications; coagulopathy and the repeated confrontation with multiple, concomitant risk factors for pressure ulcer development experienced by this population (see *Risk Factors and Risk Assessment* section of the guideline).


Critically ill individuals have unique pressure ulcer prevention and treatment needs that are addressed within the following recommendations. These recommendations are intended to supplement and not replace the general recommendations outlined in this guideline. Prevention of pressure ulcers through the use of prophylactic dressings has been investigated in emerging research conducted in a variety of populations, including those in critical care settings (see *Emerging Therapies for Prevention of Pressure Ulcers* section of this guideline).

Support Surfaces

Individuals in critical care are at a higher risk of pressure ulcers due in part to their immobility (see *Risk Factors and Risk Assessment* section of the guideline). When their medical condition precludes frequent repositioning, this risk increases. The *Support Surfaces* section of the guideline includes comprehensive recommendations on the selection of an appropriate support surface (e.g., changing from a reactive to an active support surface) for individuals at high risk of pressure ulcers.

- 1. Evaluate the need to change the pressure redistributing support surface for individuals with poor local and systemic oxygenation and perfusion to improve pressure redistribution, shear reduction, and microclimate control. Utilize additional features (e.g., turn assistance, percussion) as needed. (Strength of Evidence = C; Strength of Recommendation = )**

Only one recent study meeting inclusion criteria has been conducted on the effectiveness of support surfaces in preventing pressure ulcers specifically in critical care populations. Black et al. (2012)⁴ compared a low air loss bed with microclimate management (n = 31) to an integrated power air redistribution bed (n = 21) for preventing pressure ulcers in a cardiovascular ICU. After a mean follow up period of 5.7 days, those nursed on the low air loss bed had significantly fewer pressure ulcers (0% versus 18%, p = 0.046).

- 2. Evaluate the need to change the support surface for individuals who cannot be turned for medical reasons, including a temporary oral-pharyngeal airway, spinal instability and hemodynamic instability. (Strength of Evidence = C; Strength of Recommendation = )**

This recommendation is based on expert opinion. In some instances individuals cannot be safely repositioned due to temporary oral-pharyngeal airway, spinal instability or risk of fatality due to hemodynamic status. Indications of an individual being too hemodynamically unstable for repositioning include being actively fluid resuscitated to maintain systemic blood pressure, active hemorrhaging, life-threatening arrhythmia, or changes in hemodynamic parameters that do not stabilize within ten minutes of repositioning.⁵

Repositioning

There is extensive guidance on repositioning in the *Repositioning and Early Mobilization* section of the guideline.

1. **Initiate a repositioning schedule as soon as possible after admission. (Strength of Evidence = C; Strength of Recommendation = 👍)**

- 1.1. **Revise the repositioning schedule in response to assessment of the individual's tolerance to repositioning. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These recommendations are based on expert opinion and indirect evidence (research conducted in individuals who were at high risk of pressure ulcers but not in a critical care setting. There is excellent evidence from randomized controlled trials (RCTs)⁶⁻⁸ conducted in older adults that individuals at high risk of pressure ulcers should be regularly repositioned (indirect evidence). Prolonged periods in a stationary position will only increase the likelihood of hemodynamic instability when repositioned. For individuals who have been unable to tolerate full repositioning, Brindle et al. (2013)⁵ suggest performing a trial of repositioning every eight hours to determine if a regular repositioning schedule can be re-established. Assessment of tolerance to frequent small shifts should be conducted on an ongoing basis, allowing the individual ten minutes to attain equilibrium before determining whether the position change is tolerated.⁵

2. **Consider slow, gradual turns allowing sufficient time for stabilization of hemodynamic and oxygenation status. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is based on expert opinion. Hemodynamic instability with mobilization can occur in the critical care population. The critically ill individual often possesses poor vascular tone, a dysfunctional autonomic feedback loop, and/or low cardiovascular reserve.⁹ Autonomic dysfunction may be more pronounced in individuals with diabetes. The individual's illness and care activities may lead to an imbalance of oxygen supply and demand if the requirements during mobility and/or care activities overstretch supply.¹⁰ Finally, cardiovascular instability is often seen during position change in individuals who have experienced prolonged bedrest.

However, few individuals are truly too unstable to turn. Turning the individual more slowly or in small increments that allow adequate time for stabilization of vital signs should be considered when possible.⁵¹¹ Care activities should be planned to allow for sufficient physiological rest to meet the oxygen demand that mobilization will place on the body. Allow the critically ill individual ten minutes to attain equilibrium before assessing tolerance to a position change.^{5, 12} If manual turning is not tolerated, as evidenced by a sustained drop in blood pressure, oxygen saturation and/or an increase in heart rate, return the individual to the supine position and consider the use of continuous lateral rotational therapy (unless contraindicated).^{5, 12} Refer to the recommendations on lateral rotation within this chapter of the guideline.

3. **Consider more frequent small shifts in position to allow some reperfusion in individuals who cannot tolerate frequent major shifts in body position. (Strength of Evidence = C; Strength of Recommendation = 👍)**

Caution: Small shifts do not replace selection of a more appropriate pressure redistribution support surface when needed or turning (major shifts in body position) when possible.

This recommendation is based on expert opinion. Oertwich et al. (1995)¹³ found that small supplemental shifts in body position significantly increased perfusion measured by laser Doppler flow. Brindle et al. (2013)⁵ provide consensus recommendations to weight-shift the critically ill individual every 30 minutes and continue to reposition the individual's limbs and head hourly as tolerated.

4. **Resume routine repositioning as soon as these conditions stabilize. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is based on expert opinion. A trial repositioning every eight hours should be conducted to determine if frequent repositioning can be re-established.⁵

5. **Use a foam cushion under the full length of the calves to elevate heels. (Strength of Evidence = B; Strength of Recommendation = 👍👍)**

Individuals in critical care may be at higher risk of heel pressure ulcer development due to the use of vasoactive medications, the presence of anasarca and multiple concomitant comorbid conditions. Ideally, heels should be free of all pressure — a state sometimes called ‘floating heels’. Pressure can be relieved by elevating the lower leg and calf from the mattress by placing a foam cushion under the lower legs, or by using a heel suspension device that floats the heel. Pillows placed under the full length of the calves to elevate heels may be appropriate for short-term use in alert and cooperative individuals.

In a RCT, Cadue et al. (2008)¹⁴ evaluated the efficacy of placing a foam cushion under the legs to ‘float’ the heels free from the bed surface. Seventy individuals in intensive care were recruited, with half receiving a foam cushion and the remainder receiving no specific intervention to prevent heel pressure ulcers. Fewer heel pressure ulcers developed among the group with the foam cushions compared with the control group (8.5% versus 54.2%). Time to develop a heel pressure ulcer was shorter in the control group compared with those receiving a foam cushion (2.8 days versus 5.6 days). This small study suggests there is value in removing all pressure from the heels, but its interpretation is constrained by the lack of a formal power calculation and uncertain subject selection criteria (Level 2 study).

The knee should be in slight flexion to prevent obstruction of the popliteal vein and caution should be taken to place no pressure on the Achilles tendon. Recommendations for correct positioning during heel flotation are outlined in the guideline section *Repositioning to Prevent and Manage Heel Pressure Ulcers*.

Prone Positioning

1. **Assess critically ill individuals placed in the prone position for evidence of facial pressure ulcers with each rotation. (Strength of Evidence = C; Strength of Recommendation = 👍)**
2. **Assess other body areas (i.e., breast region, knees, toes, penis, clavicles, iliac crest, symphysis pubis) that may be at risk when individuals are in the prone position with each rotation. (Strength of evidence = C; Strength of Recommendation = 👍)**
3. **Offload pressure points on the face and body while in the prone position. (Strength of evidence = C; Strength of Recommendation = 👍👍)**

Individuals in critical care placed in the prone position may be at increased risk for the development of facial pressure ulcers. In one small case series study (n = 15) Romero et al. (2009)¹⁵ reported that 13% (2/15) of participants with severe acute respiratory distress syndrome who were nursed in a prone position for ventilation (mean time in prone position 55 ± 7 hours) developed a Category/Stage II pressure ulcer on the face.

Additional research on prone positioning conducted in operating room settings provides further guidance on preventing facial and chest pressure ulcers (see the guideline section *Special Populations: Individuals in the Operating Room*).

Lateral Rotation

Beds with lateral rotation features are often used in the critical care environment. Individuals who are too unstable to reposition frequently using standard repositioning may tolerate lateral rotation, which also provides opportunity to train the body to tolerate side-to-side movement. Lateral rotation therapy is not appropriate for individuals with unstable spinal fractures as they require positioning with multiple supports to maintain alignment.⁵

1. **Minimize shear strain when lateral rotation features are used. (Strength of Evidence = C; Strength of Recommendation = 👍)**
2. **Secure the individual with bolster pads (provided by the manufacturer) to prevent sacral shearing when lateral rotation features are selected for individuals without existing pressure ulcers. The individual should be aligned properly in the center of the surface. (Strength of Evidence = C; Strength of Recommendation = 👍)**
3. **Assess skin frequently for shear injury. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These recommendations are based on expert opinion. Lateral rotation may provide a continuous slow rotation cycle that redistributes pressure in high risk critically ill individuals. The degree of rotation can be adjusted to the individual's tolerance. Lateral rotation (usually of 40°) is a recognized therapy for individuals in respiratory distress, and specific criteria for the use of this therapy have been established.¹⁶⁻¹⁸


Whenever lateral rotation features are used, the risk for shear injury exists. Shear force tangentially strains the skin and underlying tissue (through stretching), interrupting blood flow and damaging cells. Unless the individual is properly positioned and bolstered, shearing can occur with every rotation, causing a new pressure ulcer or worsening existing ulcers. The role of prophylactic dressings in mitigating the effect of shear is discussed in the *Emerging Therapies for Prevention of Pressure Ulcers* section of the guideline.

4. **Continue to reposition the individual when using lateral rotation features. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is based on expert opinion. Lateral rotation features do not replace the need for repositioning.
5. **Re-evaluate the need for lateral rotation at the first sign of tissue injury. If indicated and consistent with medical needs, change to a support system with improved pressure redistribution, shear reduction, and microclimate control. (Strength of Evidence = C; Strength of Recommendation = 👍)**


Lateral Rotation in Individuals with Pressure Ulcers

1. **Position the individual off the pressure ulcer as much as possible. (Strength of Evidence = C; Strength of Recommendation = 👍)**
2. **Consider alternative methods of pressure redistribution (or avoid lateral rotation beds) in individuals with sacral or buttock pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)**

- 3. Inspect the pressure ulcer and the periulcer skin for shear injury with every dressing change. Shear injury may appear as deterioration of the ulcer edge, undermining, and/or as increasing inflammation of periulcer skin or the ulcer. (Strength of Evidence = C; Strength of Recommendation = )**

These recommendations are based on expert opinion. Continued use of lateral rotation may be necessary for individuals in respiratory distress. In all cases, the risks and benefits of continued lateral rotation should be weighed in individuals with existing pressure ulcers. Shear forces lead to flare of the edges of existing pressure ulcers and often cause lateral extension of existing pressure ulcers because blood flow is interrupted. Refer to the guideline section *Assessment of Pressure Ulcers and Monitoring of Healing* for comprehensive recommendations on pressure ulcer assessment.

Nutrition Management

- 1. Due to insufficient evidence to support or refute the use of specific additional nutrition interventions in critical care patients, specific additional nutrition interventions are not recommended for routine use in this population. (Strength of Evidence = C ; Strength of Recommendation = )**

Adequate protein and calories are required to support the metabolic needs and healing in critically ill patients with existing pressure ulcers. The *Nutrition for the Prevention and Treatment of Pressure Ulcers* section of this guideline provides appropriate recommendations.

In one small moderate quality prospective RCT (Level 2 study) individuals in critical care (n = 20) receiving a control isonitrogenous enteral formula showed a significant (p = 0.02) mean increase in pressure ulcer severity measured on the PUSH tool. Those in the study group (n = 20) who received an enteral feeding formula enriched with fish oil and micronutrients (vitamins A, C and E; zinc; manganese; copper and protein) did not show any worsening in pressure ulcer severity over the four week study period. The study group also showed greater mean decreases in serum C-reactive protein concentrations.¹⁹ Additional research is needed to definitively recommend the addition of fish oil to enteral feeding formulations in practice.

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OLDER ADULTS

Introduction

Older adults are particularly vulnerable to pressure ulcers. As discussed in the *Risk Factors and Risk Assessment* section of the guideline, advanced age is identified as a predictor of pressure ulcers.¹⁻⁴ With other significant risk factors occurring with greater frequency in older adults, including decline in general and mental health status, sensory perception deficits, increased moisture (e.g., from incontinence), declining nutritional status, fragile skin and mobility limitations, the presence of cumulative risk factors places older adults at a higher risk of pressure ulcers.

As reported in the *Prevalence and Incidence of Pressure Ulcers* section of the guideline, individuals in aged care settings experience pressure ulcers at a higher rate than those in acute care settings. Pressure ulcer prevalence in aged care ranges from 4.1% to 32.2%,⁵ and variations are primarily associated with study methodologies and the age of participants (i.e., 'old' versus 'older old').^{6,7} Facility-acquired pressure ulcer rates may be higher in aged care than any other clinical setting (see *Prevalence and Incidence of Pressure Ulcers*). Additionally, residents of long-term care facilities experience higher prevalence of multiple risk factors for pressure ulcer development than community-dwelling older adults.⁸

The recommendations in *Special Populations: Older Adults* are intended to supplement and not replace the general recommendations outlined in this guideline.

Assessment and Care Planning

- 1. Consider the individual's cognitive status when conducting a comprehensive assessment and developing a pressure ulcer prevention and/or treatment plan. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. The increasing prevalence of cognitive impairment associated with aging⁹ may impact the risk and general assessment process, particularly when relying on self-reported information. Pressure ulcer prevention and treatment plans should be appropriate to the cognitive skills of the individual in order to promote adherence.

- 1.1. Incorporate the individual's cognitive ability into the selection of a pain assessment tool. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. As discussed in the *Pain Assessment and Treatment* section of the guideline, pain assessment tools should be appropriate to the individual's cognitive level. Current evidence suggests that the McGill Pain Questionnaire (MPQ), which is validated in populations with pressure ulcer pain,¹⁰ provides the most reliable pain assessment for cognitively impaired individuals.¹¹ The FACES is also highly reliable for pain assessment in individuals with decreased verbal and abstract thinking.¹²

- 2. Ensure pressure ulcers are correctly differentiated from other skin injuries, particularly incontinence-associated dermatitis or skin tears. (Strength of evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Individuals in the older population are at risk for pressure ulcers, incontinence-associated dermatitis, and skin tears. The rationale for accurate differentiation of these injuries is based on the differing etiology of these lesions, and the differing prevention and management strategies required.¹³ Accuracy and reliability in differential diagnosis is reported to be low for nurses attempting to distinguish incontinence-associated dermatitis or moisture lesions from Category/Stage II pressure ulcers.¹⁴⁻¹⁶ The guideline sections *Classification of Pressure Ulcers* and *Assessment of Pressure Ulcers and Monitoring of Healing* outline other relevant considerations in differentiation and classification.

3. Set treatment goals consistent with the values and goals of the individual. (Strength of Evidence = C; Strength of Recommendation = 👍)

3.1. Engage the family or legal guardian when establishing goals of care and validate their understanding of these goals. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based on expert opinion. Goals of care should be established in collaboration with the individual and his or her significant others and should be reflective of the older adult's values and goals of care, particularly as end-of-life approaches. To the extent possible (determined by comorbidity and stage of life) allow the individual to direct care. The individual and his or her significant others are integral to development of an individualized prevention and treatment plan, including management of associative factors such as pressure ulcer pain.¹⁷

For older adults, implementation of strategies specific to pressure ulcers and their diagnosis, prevention, and treatment may be challenging and in some instances inconsistent with what is considered best practices for care. The functional and cognitive status of the individual, stage of life, level of resources (particularly in community care settings) and involvement of family caregivers will all influence care goals and the appropriateness of specific prevention and treatment strategies for the individual.

4. Educate the individual and his or her significant others regarding skin changes in aging and at end of life. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. It is important that the individual and their family and caregivers are aware that as death approaches the body's vital organs, including the skin, will begin to shut down. This change in functioning may result in the skin becoming compromised and wounds that would usually be preventable, such as pressure ulcers, may develop, even though prevention strategies are in place.¹⁸

Care of Vulnerable Aged Skin

As the individual ages, there is deterioration in both the structure of the skin, and in its functional ability. Progressive loss of skin integrity occurs as a result of both intrinsic factors (e.g., loss of epidermal thickness, flattening of the dermal-epidermal junction, decreased cell turnover and collagen production) and extrinsic factors (e.g., long term exposure to environmental elements).¹⁹ As a result, aging skin requires particular care and attention.

1. Protect aged skin from skin injury associated with pressure and shear forces. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. The recommendations for reducing pressure and shear forces that are detailed throughout this guideline are relevant to the older adult. Pay particular attention to protecting the older adult's skin during manual handling, repositioning, and use of manual handling devices.

2. Use a barrier product to protect aged skin from exposure to excessive moisture in order to reduce the risk of pressure damage. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based on expert opinion. As discussed in the *Risk Factors and Risk Assessment* section of the guideline, the impact of excess skin moisture on an individual's risk for pressure ulcers should be considered. Moisture remaining in contact with skin for a prolonged period can damage the skin's integrity, thereby increasing the risk of pressure ulcer. The presence of moisture may increase friction and shear exerted on the skin surface, and chemical irritants in urine and/or feces contribute to skin breakdown; both of which increase the risk of pressure ulcer development. Bacterial or fungal pathogens contained in effluent increase the risk of infection in existing pressure ulcers.²⁰

Use of skin protectants shield the stratum corneum from exposure to excess moisture and irritants.²¹ Selection of skin care products is discussed in the *Preventive Skin Care* section of the guideline.

- 3. Select atraumatic wound dressings to prevent and treat pressure ulcers in order to reduce further injury to frail older skin. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. When the adhesive attachment to the individual's skin of a wound dressing has greater strength than the cell attachment within the skin there is a risk that attempted removal of the wound dressing may separate the epidermal layers, or separate the epidermis from the dermis. Because both intrinsic and extrinsic factors contribute to structural deterioration of aged skin, older adults are at a heightened risk of medical adhesive-related skin injury.²²

- 4. Develop and implement an individualized continence management plan. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Incontinence can lead to prolonged skin exposure to excess moisture and chemical irritants in urine and feces. In addition, occlusion resulting from the use of an incontinence aid can alter the microclimate of the skin. The overall result can be inflammation, erythema, erosion, and denudation with decreased tolerance to other forms of skin damage, such as that associated with prolonged exposure to pressure or shear.¹³

Repositioning

The *Repositioning and Early Mobilization* section outlines general recommendations for repositioning that remain appropriate for older adults. The general principles behind repositioning and early mobilization²³⁻²⁵ are applicable to older adults in all clinical settings.

- 1. Regularly reposition the older adult who is unable to reposition independently. (Strength of Evidence = A; Strength of Recommendation = 👍👍)**

Repositioning of an individual is undertaken to reduce the duration and magnitude of pressure over vulnerable areas of the body and to contribute to comfort, hygiene, dignity, and functional ability. Regular and consistent movement to facilitate redistribution of mechanical load is especially important to all older adults because of an increased risk for compromise in skin integrity as a result of the aging process and chronic conditions affecting mobility and tissue perfusion.

Three randomized controlled trials (RCTs) conducted in aged care facilities support this recommendation.²⁶⁻²⁸ In a RCT involving 838 nursing home residents at risk for pressure ulcers, Defloor et al. (2005)²⁶ found four hourly repositioning of an older adult on a viscoelastic mattress resulted in a significant reduction in the incidence of Category/Stage II and more severe pressure ulcers compared to the regular care in the facility (odds ratio [OR] = 0.12; 95% CI 0.03 to 0.48). Regular repositioning was not part of regular care provided to the control group; however, a wide range of different support surfaces (e.g., water mattresses, alternating mattresses, sheepskins or gel cushions) were used in the control group (Level 1 study).

Moore et al. (2011)²⁸ conducted a study among older adults in 12 aged care facilities. In the experimental group (n = 99), participants were repositioned every three hours using the 30° tilt (left side, back, right side, back) between 8pm and 8am. In the control group (n = 114), participants received routine repositioning every six hours using a 90° lateral rotation between 8pm and 8am. Day time care remained routine for all facilities. Fewer participants in the experimental group developed a pressure ulcer (3% versus 11%; p = 0.03). The OR of a pressure ulcer was 0.243 (95% CI 0.067 to 0.879, p = 0.034). The frequency of turning in the control group was every six hours, which may not be considered standard care in many facilities (Level 2 study).

In a RCT conducted by Vanderwee et al. (2007)²⁷ involving 235 older adults, the experimental group received a repositioning regimen consisting of two hours in a lateral position alternating with four hours in a supine position while the control group was repositioned every four hours, first in lateral and then

in supine position. All individuals received a viscoelastic foam mattress. This study demonstrated that lying for a shorter time in the lateral position on a pressure redistributing mattress did not result in significantly fewer Category/Stage II pressure ulcers ($p = 0.40$); however, the study did not recruit sufficient participants to meet the desired power (Level 2 study).

2. **Consider the condition of the individual and the pressure redistribution support surface in use when deciding if repositioning should be implemented as a prevention strategy. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Regular positioning is not possible for some individuals because of their medical condition, and an alternative prevention strategy such as providing a high-specification mattress or bed may need to be considered.

3. **Exercise caution in position selection and manual handling technique when repositioning the older adult. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Older adults may have an increased propensity to both hemodynamic instability and decreased respiratory function as a result of acute and/or chronic cardiovascular and respiratory conditions.^{29, 30} Sudden change in position, changes in position greater than 30° elevation, and use of the prone position may result in hypotension and/or hypoventilation.²⁹ Consider more frequent small shifts in position to allow some reperfusion in individuals who cannot tolerate frequent major shifts in body position. Oertwich et al. (1995)³¹ found that small supplemental shifts in body position significantly increased perfusion measured by laser Doppler flow. De Laat et al. (2007)³² determined that turning critically ill individuals more slowly or in small increments allowed time for stabilization of vital signs. This strategy could also be appropriate in the management of older adults.

Some positions may be more difficult for older adults to tolerate due to musculoskeletal conditions and other comorbidities. Frail elderly tissue is often less tolerant of the pressure, friction and shear forces normally exerted during repositioning. Health professionals should be aware of the need to handle these individuals gently during repositioning.

4. **Frequently reposition the head of older adults who are sedated, ventilated or immobile. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This statement is based on expert opinion. Although more commonly seen in pediatrics, older adults, particularly those who are bedbound, remain at risk of occipital pressure ulcers.³³ Frequent head repositioning and removal of hair accessories that may cause pressure (e.g., hair bands) will assist in reducing the risk.

Medical Device Related Pressure Ulcers

1. **Consider older adults with medical devices to be at risk for pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. The use of any medical device for diagnostic or therapeutic purposes places individuals at risk for localized pressure from the device and compromised skin and tissue perfusion unless the device is off-loaded or shifted in position to redistribute local pressure. As noted in the section on *Medical Device Related Pressure Ulcers*, the resultant pressure ulcer generally closely conforms to the pattern or shape of the device.³⁴

Although research on medical device related pressure ulcers has been primarily conducted in acute and critical care settings and pediatric populations, medical devices are commonly used in older adults who have fragile skin and cumulative risk factors for pressure ulcers. This population is at high risk for injury related to medical device use. In addition to the medical devices referred to in the *Medical Device Related Pressure Ulcers* section of the guideline, the following devices are frequently used in the care of older adults:

- immobilizers,
- plaster casts,
- Foley catheters,
- fecal containment devices,
- percutaneous endoscopic gastrostomy (PEG) and nasogastric feeding tubes,
- nasal cannulas,
- graduated compression stockings, and
- restraints.

2. Ensure that medical devices are correctly sized and fit appropriately to avoid excessive pressure. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Removal of, or changing, the device when clinically feasible whenever a pressure ulcer occurs due to a medical device (as recommended in the guideline section on *Medical Device Related Pressure Ulcers*) may be less practical when caring for older adults due to limited care alternatives. Thus, the recommendations for careful selection and fitting of a medical device merit strong consideration when caring for older adults.

3. Consider using a prophylactic dressing for preventing medical device related pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based on expert opinion. Research on the role of prophylactic dressings for the prevention of device related pressure ulcers³⁵⁻³⁹ has been conducted in trauma and pediatric populations. Prophylactic dressings should be selected and implemented with caution in older adults due to their thin and often fragile skin.

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INDIVIDUALS IN THE OPERATING ROOM

Introduction

Pressure ulcers frequently occur in individuals in surgical units or wards. Pressure ulcer incidence directly attributable to the operating room ranges between 4% and 45%.¹⁻³ It is generally assumed that pressure ulcers that occur in the postoperative period are often caused during the intraoperative (surgical) period.² The pressure ulcer incidence should be interpreted with some caution, as it is not always clear when a pressure ulcer developed. The time between development of a pressure ulcer and the point when a pressure ulcer becomes visible at the skin varies between several hours to three-to-five days.⁴ However, some lesions are so clearly related to restraints or posture during surgery, or occur so shortly after surgery, that there can be little doubt about the causation. Research also shows that pressure ulcers caused during surgery can be misdiagnosed as burns.⁵

During surgery, patients are immobile, positioned on a relatively hard surface, are not able to feel the pain caused by pressure and shearing forces, and are unable to change their position in order to relieve pressure. The duration of immobility is longer than the duration of the surgery; patients are already immobile during the preoperative period and often remain in the same position until their arrival in the recovery room.

Recommendations

1. Consider additional risk factors specific to individuals undergoing surgery including:

- **duration of time immobilized before surgery;**
- **length of surgery;**
- **increased hypotensive episodes during surgery;**
- **low core temperature during surgery; and**
- **reduced mobility on day one postoperatively. (Strength of Evidence = C; Strength of Recommendation = 🇨🇪🇨🇪)**

Studies on the association between delay in surgery and pressure ulcer risk have been conducted in older adults with hip fractures. In a prospective cohort study, Al-Ani et al. (2008)⁶ found the median wait time from admission to surgery was 24 hours (range 2.88 to 331 hours). After adjusting for age, American Society of Anesthesiologists (ASA) score, pre-fracture mobility status and duration of surgery, the adjusted odds ratio (OR) of experiencing a pressure ulcer increased as the delay before surgery increased. The OR of experiencing a pressure ulcer if surgery was delayed by 24 hours was 2.19 (95% confidence interval [CI] 1.21 to 3.96, $p < 0.01$) and OR for a 48 hour delay for surgery was 4.34 (95% CI 2.34 to 8.04, $p < 0.001$). In a lower quality retrospective review, Lefavre et al. (2009)⁷ found no significant difference in incidence of pressure ulcers for patients who experienced a 24 hour delay, but OR of a 48 hour delay was 2.29 (95% CI 1.19 to 4.40, $p = 0.01$). A multivariate analysis of data from a second retrospective record review found an adjusted OR for pressure ulcer when surgery was delayed of 1.33 (95% CI 0.96 to 2.05, $p = 0.20$).⁸ The prospective study by Al-Ani et al. (2008)⁶ had a stronger design, and included only Category/Stage II or greater pressure ulcers. In a comparison of outcomes and complications between individuals who underwent an early spinal surgery protocol (within 24 hours of admission, $n = 42$) versus those who had delayed surgery (24 hours or longer following admission, $n = 70$), pressure ulcer incidence was lower in the early surgery group (2.4% versus 8.6%, $p < 0.05$).⁹

The longer the surgical procedure, the greater the risk of developing a pressure ulcer. Schoonhoven et al. (2002)¹⁰ followed 208 individuals undergoing surgery of four hours or longer (Level 4 study). Multiple logistic regression analysis found a significant association between length of operation and occurrence of Category/Stage II to IV pressure ulcers (OR = 1.01, 95% CI 1.004 to 1.009%, for every minute longer of operation time), consistent with previous studies.^{11,12}

Nixon et al. (2000)¹³ performed a study of 446 individuals undergoing surgery. They identified prognostic factors for pressure ulcer development using multivariate analysis, and found that increased

hypotensive episodes resulted in an increased probability of developing a pressure ulcer. In the same study, Nixon et al. (2000)¹³ also found that a low core temperature increased the probability for pressure ulcer development.

Reduced mobility on the first day following surgery was also shown to be associated with an increased probability for pressure ulcer development.¹³

- 2. Use a high specification reactive or alternating pressure support surface on the operating table for all individuals identified as being at risk of pressure ulcer development. (Strength of Evidence = B; Strength of Recommendation = Ⓢ)**

Several operating room support surfaces that encourage pressure redistribution have been developed. Nixon et al. (1998)¹⁴ conducted a randomized controlled trial (RCT) involving 446 individuals undergoing elective major general, gynecological, or vascular surgery. Participants included were aged 55 years or above, and their surgical procedure was planned to be at least 1.5 hours in length. In this trial, a viscoelastic polymer pad was compared to a standard table mattress. The provision of a warming mattress was standardized for both groups. The pressure ulcer incidence in the viscoelastic polymer pad group (11%) was significantly lower than in the standard mattress group (20%) (OR = 0.46; 95% CI 0.26 to 0.82; $p = 0.010$) (Level 1 study).

Feuchtinger et al. (2006)¹⁵ performed a RCT that included 175 individuals undergoing cardiac surgery. The participants were aged at least 18 years, and had a minimum of 1.5 hours on the operating table. In the experimental group, participants were given a 4 cm thermoactive viscoelastic foam overlay combined with a water-filled warming mattress during surgery. In the control group, only a water-filled warming mattress was used. Feuchtinger et al. (2006)¹⁵ found a non-significant increase in pressure ulcers in the intervention group compared with the control group (17.6% versus 11.1%, $p = 0.22$) (Level 2 study). Two RCTs evaluated the use of an alternating pressure air mattress (a multi-segmented pad with more than 2,500 air cells enclosed in a waterproof cover) during and after surgery. In the control group, participants were on a gel mattress during surgery and a standard mattress after surgery.^{16, 17} Both studies included individuals aged 18 years and older with an anesthesia time of four hours or more. Aronovitch et al. (1999)¹⁶ studied 217 people undergoing surgery and reported a pressure ulcer incidence of 8.7% in the control group and no pressure ulcers in the intervention group ($p < 0.005$) (Level 2 study). Russell et al. (2000)¹⁷ studied 198 individuals undergoing cardiothoracic surgery, reporting pressure ulcer incidence of 7% in the control group and 2% in the intervention group ($p=0.17$) (Level 2 study). However, from these studies, it cannot be concluded whether the reduction in pressure ulcers was related to the multi-segmented alternating pressure air mattress or to the postoperative pressure redistribution, or to a combination of both.

Interface pressures in individuals on an operating table can be very high. In a lab study of interface pressure measurements among healthy volunteers, Defloor et al. (2000)¹⁸ found that pressure was most reduced on viscoelastic foam mattresses, compared to foam mattresses and gel mattresses (Level 5 study). In another lab study, Scott et al. (1999)¹⁹ measured interface pressure in healthy volunteers lying on four types of foam mattresses with different density and/or cover. They found that the foam mattress with lowest density and a neoprene cover resulted in the lowest interface pressure (Level 5 study).

Additional information on high specification support surfaces, including discussion on their characteristics and recommendations on their maintenance, are found in the guideline section *Support Surfaces*.

- 3. Position the individual in such a way as to reduce the risk of pressure ulcer development during surgery. (Strength of Evidence = C; Strength of Recommendation = ⓈⓈ)**

In a laboratory study, Defloor et al. (2000)¹⁸ showed that interface pressure was lowest when an individual was positioned in the supine position, compared to other surgical positions (Level 5 study). The position during the operation is dictated by surgical needs; however, the use of padding should be considered to protect bony prominences.

For additional information on the influence of positioning see the guideline section *Repositioning and Early Mobilization*.

3.1. Use additional support surfaces (e.g. facial pads) to offload pressure points on the face and body while in the prone position. (Strength of evidence = C; Strength of Recommendation = 🍌🍌)

Studies that have examined the impact of placing individuals in the prone position in the operating room have their limitations and their findings can only be applied to other settings to a limited extent. However, the evidence that is available indicates that individuals who are placed in a prone position should have bony prominences (e.g., breast region, knees, toes, penis, clavicles, iliac crest and symphysis pubis) and their faces supported with the best available pillows to prevent pressure ulcer formation on the forehead or chin. The evidence also suggests that patients who are placed in a prone position must have their position changed as frequently as possible in the operating room as they are at high risk of pressure ulcer formation irrespective of the selection of pressure redistributing surface.

In a non-randomized, non-blinded observational study of people receiving spinal surgery, 73% of the participants placed in the prone position with 2 cm thick visco-elastic pads (VP) and 77% of those placed in a prone position with 10 cm thick high density foam (HDF) had non blanchable erythema or redness on their iliac and chest pressure points. Thirty minutes post operatively the incidence of pressure ulcers was higher in the HDF group, but not statistically significant ($p > 0.05$).²⁰ One individual in the VP group had a Category/Stage II pressure ulcer after 48 hours, but mean interface pressure was significantly lower with the VP ($p < 0.001$).²⁰ The findings are limited by the study design, recruitment of a small sample ($n = 30$) and the short follow up period (48 hours) (Level 3 study).

In a blinded RCT²¹ participants admitted for elective surgery requiring a standard prone position were randomized to receive a disposable polyurethane foam facial pillow ($n = 22$); a disposable polyurethane foam head positioner ($n = 22$); or a neoprene air filled bladder dry flotation facial pillow ($n = 22$). Ten participants on the polyurethane foam facial pillow developed pressure ulcers (eight Category/Stage I pressure ulcers and two Category/Stage II pressure ulcers) and none of the participants who used the other pillows had any evidence of pressure damage. The interface pressures at the forehead and chin were significantly lower for participants receiving the polyurethane foam head positioner in comparison with the two facial pillows ($p < 0.05$), and the dry flotation facial pillow had significantly lower forehead interface pressures than the polyurethane foam facial pillow ($p < 0.05$).²¹ The results of this study are limited by the fact that the participants were not stratified according to risk of pressure ulcers and the length of time that each individual was in prone position was not reported (Level 2 study).

3.2. Do not position the individual directly on a medical device unless it cannot be avoided. (Strength of Evidence = C; Strength of Recommendation = 🍌🍌)

Individuals with medical devices are at an increased risk of pressure ulcers. The heavy burden of technology and equipment utilized in the operating room renders the individual particularly vulnerable to the risk for device related pressure ulcers. Additionally, the individual undergoing surgery may be at risk for medical device related pressure ulceration due to an increase in risk factors, including impaired sensation, moisture under the device, poor perfusion, altered tissue tolerance, and edema.²² The guideline section on *Medical Device Related Pressure Ulcers* includes additional recommendations for reducing risk associated with external devices in a variety of clinical settings, including the operating room.

4. Ensure that the heels are free of the surface of the operating table. (Strength of Evidence = C; Strength of Recommendation = 🍌🍌)

Ideally, heels should be free of all pressure — a state sometimes called ‘floating heels’. Pressure can be relieved by elevating the lower leg and calf from the mattress with placement of a pillow under the

lower legs, or by using a heel suspension device that floats the heels. Consequently, the pressure will instead spread to the lower legs and the heels will no longer be subjected to pressure.

4.1. Use heel suspension devices that elevate and offload the heel completely in such a way as to distribute the weight of the leg along the calf without placing pressure on the Achilles tendon. (Strength of Evidence = B; Strength of Recommendation = 🍌🍌)

Heel suspension devices are preferable for immobilized individuals in the operating room. A laboratory study investigated interface pressures at the calf, heel, Achilles tendon and lateral malleolus associated with a variety of heel suspension devices, a pressure redistribution support surface mat and a regular operating table. Participants (n = 116) were recruited from a vascular laboratory. Each participant was consecutively positioned with each of the study intervention heel suspension devices and support surfaces. A pressure mapping system measured interface pressure two minutes after each positioning. There was significantly lower interface pressures at the heel for all heel suspension devices (all $p < 0.001$) compared with the pressure redistribution support surface mat and with the regular operating table. The heel suspension device that provided heel elevation through distribution of the weight of the leg along the calf provided significantly lower interface pressures at both the Achilles tendon and the lateral malleolus²³ (indirect evidence).

Donnelly et al. (2011)²⁴ conducted a RCT comparing complete offloading of the heel using a commercial heel suspension device to standard care (with no heel offloading) for prevention of heel pressure ulcers. The researchers recruited 239 participants aged over 65 years who were admitted to a fracture trauma unit with hip fractures that occurred within the previous 48 hours. The primary outcome of interest was the occurrence of a new Category/Stage I or greater pressure ulcer on the heels or other anatomical sites. The intervention group (n = 120 with 9 withdrawals) had significantly fewer pressure ulcers (7% versus 26%, $p < 0.001$) at any anatomical site than the control group (n = 119 with 3 withdrawals) and developed no pressure ulcers on the ankles, feet or heels, compared to 29 occurrences in the control group ($p < 0.001$). Kaplan-Meier survival curves indicated participants in the control group were more likely to suffer pressure damage at all points in time (log rank, $p = 0.001$). The hazard analysis indicated that when considering the effect of multiple clinical and pathological factors that might be specific risk factors, participants randomized to the treatment group were five times less likely to develop pressure damage (hazard ratio = 0.21, 95% CI 0.008 to 0.54) than the control group (hazard ratio = 1.00). This study was not conducted in an operating room environment; however, the results are directly applicable (Level 2 study).

5. Position the knees in slight flexion when offloading the heels. (Strength of Evidence = C; Strength of Recommendation = 🍌)

Hyperextension of the knee causes obstruction of the popliteal vein, and this could predispose an individual to deep vein thrombosis (DVT). Positioning the knees in slight flexion prevents popliteal vein compression and decreases the risk of perioperative DVT. The popliteal veins of 50 individuals under general anesthesia were studied using duplex ultrasonography. They examined the diameter of the popliteal vein when the knees were flexed and extended, and found a significant reduction in popliteal vein diameter in extension, compared with the diameter in flexion ($p < 0.001$).²⁵ There is further evidence from a study looking at the association between popliteal vein compression and the likelihood of presenting with a DVT.²⁶ Individuals who presented to a vascular laboratory to check for the presence of a DVT were also studied for the presence of popliteal vein compression. Of the 54 eligible patients, 16 had a DVT. Five of 18 individuals with popliteal vein compression had a distal DVT (27.7%), while five of 36 individuals without popliteal vein compression had distal DVT (16.7%). The difference was statistically significant (relative risk 2.9, $p < 0.05$) (indirect evidence).

6. Consider pressure redistribution prior to and after surgery. (Strength of Evidence = C; Strength of Recommendation = 🍌🍌)

- 6.1. Place the individual on a high specification reactive or alternating pressure support surface both prior to and after surgery. (Strength of Evidence = C; Strength of Recommendation = 🍌)**

This statement is based on expert opinion. To minimize the time that pressure and shear are exerted on specific pressure points, individuals at risk for pressure ulcers should be placed on pressure redistributing mattresses both preoperatively and postoperatively (see the *Support Surfaces* section of the guideline for further discussion).

- 6.2. Document the individual's position and the anatomical areas under increased interface pressure during surgery. (Strength of Evidence = C; Strength of Recommendation = 🍌🍌)**

- 6.3. Position the individual in a different posture preoperatively and postoperatively than the posture adopted during surgery. (Strength of Evidence = C; Strength of Recommendation = 🍌)**

This statement is based on expert opinion. The individual will be immobilized for an extended period of time during surgery. This can cause reduced tissue perfusion at the pressure points.^{2,10} Positioning the individual in a different posture wherever possible allows for other pressure points to be loaded. Thus, the length of the period in which tissue is compromised is shortened, and the risk of developing a pressure ulcer decreases.¹⁸ In order for health professionals working in the post anesthesia care unit and hospital ward to monitor the skin's condition and to select appropriate positions following surgery, clear documentation of the individual's position during surgery is required.

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INDIVIDUALS IN PALLIATIVE CARE

Introduction

Sufficient informed clinical consensus exists to support pressure ulcer management in an individual receiving palliative care, despite the ethically understandable absence of randomized controlled trials comparing approaches in human subjects.¹⁻¹² Palliative care is a high risk setting for pressure ulcer development, as it often involves individuals at the end of life who experience organ system failure. “Within palliative care, it is never going to be possible to eradicate pressure [ulcers] because of the multiple risk factors experienced by the patients.”^{13, p. 38} Skin is the largest organ of the body, and it is subject to failure like any organ is when the body is dying. Because of this, skin breakdown is inevitable for many individuals at the end of life,^{2, 4, 8, 10, 12-16} and healing often is not a realistic goal.^{3, 5, 9, 11, 13} In addition, new pressure ulcers may occur in this vulnerable population.¹ In adults with severe end-stage dementia, the presence of pressure ulcers has been associated with high six month mortality rates.¹⁷

It is important to implement preventive and treatment interventions in accordance with the individual’s wishes, and with consideration to overall health status. The goals of palliative wound care are comfort for the individual and limiting the impact of the wound on quality of life, without the overt intent of healing.¹⁸

Various aspects of evidence-based pressure ulcer management are discussed from the perspective of the individual receiving palliative care. These recommendations should be considered in conjunction with those outlined in the general recommendations sections of this guideline; however, health professionals are encouraged to adapt and modify care in accordance with the goals and wishes of the individual and his or her significant others.

Principles

The following general principles should guide pressure ulcer management in individuals receiving palliative care.

- Palliative care is focused on preventing and relieving suffering of the individual with life-threatening illness and his or her significant others through identification, assessment and relief of distressing physical, psychosocial and spiritual issues, and pain, while neither hastening nor prolonging death.¹⁹
- Goals of care should be established in collaboration with the individual and his or her significant others. To the extent possible, allow the individual to direct care.
- Palliative pressure ulcer care is not ‘lack of care’, but care focused on comfort and limiting the extent or impact of the wound.¹⁸ Prevention of new pressure ulcers remains important; however, during the period of active dying, comfort and/or the individual’s preference may override implementation of active prevention strategies.

Patient and Risk Assessment

- 1. Complete a comprehensive assessment of the individual. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Assessment of the individual, the risk for development of a pressure ulcer, the risk for development of additional pressure ulcers, and the ulcer itself (if present) are important. Patient assessment should include:^{2, 4, 7, 20-26}

- any co-morbid health problems, including combination(s) of problems;
- medications;
- nutritional status;
- risk factors, including immobility and incontinence;
- diagnostic test results;
- psychosocial implications;

- environmental resources; and
- wishes and concerns of the individual and significant others.

It is also essential to continue to regularly assess risk for development of new pressure ulcers, particularly in light of the progressive deterioration in the individual's condition. Carefully consider the risks and benefits of health care transfers, for example transferring from a long term care facility to an acute care hospital, because transfers between facilities are associated with an increased incidence of pressure ulcers at the end of life.²⁷

1.1. Consider using the Marie Curie Centre Hunters Hill Risk Assessment Tool, specific to adult individuals in palliative care. (Strength of Evidence = C; Strength of Recommendation = 🗨️)

This statement is based on expert opinion. A structured approach to pressure ulcer risk assessment may be achieved through the use of a risk assessment tool^{28, 29} in conjunction with a comprehensive skin assessment, both of which are refined by using clinical judgment informed by knowledge of key risk factors for pressure ulcer development. Several general risk assessment tools are available to help professionals objectively rate contributing factors for additional ulcers and serve as a basis for pressure ulcer prevention strategies.³⁰ Recommendations on structured pressure ulcer risk assessment are in the *Risk Factors and Risk Assessment* section of the guideline.

The Marie Curie Centre Hunters Hill Risk Assessment Tool was developed specifically for the palliative care population. It has the same subscales as the Braden Scale (see *Risk Factors and Risk Assessment*), but adds a seventh subscale of activity in bed.^{3, 31}

Pressure Redistribution

1. Reposition and turn the individual at periodic intervals, in accordance with the individual's wishes, comfort and tolerance. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. Comfort is of primary importance and may supersede prevention and wound care for individuals who are actively dying or have conditions causing them to have a single position of comfort.

Establish a flexible, individualized repositioning schedule based on the:

- individual's goals, wishes, comfort and tolerance;
- pressure redistribution characteristics of the support surface;
- current clinical status; and
- combination of co-morbid conditions, as medically feasible.

The *Repositioning and Early Mobilization* section outlines general recommendations for repositioning that remain appropriate for individuals receiving palliative care.

- 1.1. Pre-medicate the individual 20 to 30 minutes prior to a scheduled position change for individuals who experience significant pain on movement. (Strength of Evidence = C; Strength of Recommendation = 👍)**
- 1.2. Consider the individual's choices in turning, including whether she/he has a position of comfort, after explaining the rationale for turning. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
- 1.3. Consider changing the support surface to improve pressure redistribution and comfort. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
- 1.4. Strive to reposition an individual receiving palliative care at least every 4 hours on a pressure redistributing mattress such as viscoelastic foam, or every 2 hours on a regular mattress. (Strength of Evidence = B; Strength of Recommendation = 👍)**

Four turning schedules were tested in a randomized controlled trial (RCT) study of 838 at-risk nursing home residents: every 2 hours or every 3 hours on a standard institutional mattress, and every 4 hours or every 6 hours on a viscoelastic foam (VEF) mattress. A significant reduction in pressure ulcer incidence was noted among residents turned every 4 hours on the VEF mattress as compared to the other three groups³² (Level 1 study).

See the *Support Surfaces* section for more evidence on support surfaces and their use in prevention and treatment of pressure ulcers.

- 1.5. Document turning and repositioning, as well as the factors influencing these decisions (e.g., individual wishes or medical needs). (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. Immobility is a known factor associated with pressure ulcer development^{2, 4, 20-22, 24-26, 33-35} and quality of life.¹ Infrequent repositioning due to inadequate staffing can contribute to pressure ulcer formation and reduced healing rates in terminally ill individuals.³⁶ A Swedish study of 98 hospice patients documented that physical activity and mobility were significantly associated with pressure ulcer development.²³ “The frail elderly patient’s ability to successfully heal chronic wounds is inextricably linked to the degree of their immobility.”^{1, p. 215} However, many individuals receiving palliative care prefer a single position for comfort, and turning and positioning may only serve to increase their pain and discomfort.^{1, 6, 34, 37, 38} When an individual is actively dying, interventions to prevent and/or treat a pressure ulcer are often superseded by the need to promote comfort by minimizing turning and repositioning and allowing the individual to determine frequency of turning and choice of position.^{6, 23, 34, 37, 38}

More frequent position changes may be possible with the use of opiates and/or sedatives to control pain. It is important to weigh the pros and cons of medication administration, as it can lead to a decrease in spontaneous movements, which in turn is often counter to proper cancer pain relief and promotion of comfort.³⁹ An individualized, patient-directed approach is in order.

Nutrition and Hydration

- 1. Strive to maintain adequate nutrition and hydration compatible with the individual’s condition and wishes. Adequate nutritional support is often not attainable when the individual is unable or refuses to eat, based on certain disease states. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
- 2. Offer nutritional protein supplements when ulcer healing is the goal. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These statements are based on expert opinion. Adequate fluid intake and maintenance of serum protein levels are needed for wound healing, although this is not always achievable in the frail elderly or an individual at end of life.^{1, 40} Additional assistance at mealtimes is often required by individuals to prevent weight loss that may increase the risk of pressure injury and poor healing.³⁶ The overriding concerns in palliative care are to provide comfort and minimize symptoms. If providing supplemental nutrition assists in providing comfort to the individual and is mutually agreed upon by the individual, family caregivers, and health professional, then supplemental nutrition (in any form) is very appropriate for palliative wound care. If the individual’s condition is such that to provide supplemental nutrition (in any form) increases discomfort and the prognosis is expected to be poor, then providing supplemental nutrition should not be a concern and is not appropriate for palliative wound care. An individual receiving palliative care who does not have ulcer healing as a goal can be allowed to consume the type and amount of food and fluids as desired.¹ See *Nutrition for Preventing and Treating Pressure Ulcers* section for more information on nutritional requirements to support healing.

Pressure Ulcer Care

An individual receiving palliative care whose body systems are shutting down often lacks the physiological resources necessary for complete healing of the pressure ulcer. As such, the goal of care may be to maintain or improve the status of the pressure ulcer rather than heal it.³⁹ Alternatively, as the individual nears death, the skin may be the first organ to be compromised and actually fail, with other systems following the downward trend.¹⁸ The Toronto Symptom Assessment System for Wounds can be used to determine concerns of the individual that should be addressed, including pain, exudate, odor, itchiness and cosmetic appearance.⁴¹

Some, but not all, pressure ulcers in individuals receiving palliative care will heal.^{9, 11} Non-healing, chronic pressure ulcers remain in an inflammatory state, further interfering with the potential to heal.⁴² Masaki et al. (2007)³⁹ found no statistically significant difference for pressure ulcer healing time between individuals with and without cancer. McNees et al. (2007)⁴³ analyzed 36,000 wound assessments, half conducted on participants with and half on participants without cancer. The two groups were sub-divided equally into those with and those without a pressure ulcer. They found that significantly more individuals without cancer had healed ulcers compared with those with cancer (78% versus 44%, $p = 0.018$). Individuals with cancer and non-healing ulcers had significantly more risk factors than those with a wound that healed (mean 6.46 versus 2.78). It is important to note that pressure ulcers *did* heal in 44% of participants with cancer.

In a prospective study of participants with advanced disease ($n = 282$), Maida et al. (2012)⁴⁴ found that 18.9% of participants with Category/Stage I pressure ulcers and 10.4% of participants with Category/Stage II pressure ulcers achieved complete healing before death. However, only 4% (one participant) with a Category/Stage III pressure ulcer showed complete healing, and none of the participants with Category/Stage IV or unstageable pressure ulcers achieved healing (Level 5 study). In a similar study, terminally ill nursing home residents ($n = 117$, 64 of whom had pressure ulcers) were followed to evaluate healing of pressure ulcers and factors that contributed to ulcer development.³⁶ This study found that some Category/Stage I, II or III pressure ulcers healed before death (46%, 29.8% and 20% respectively); however, no Category/Stage IV or unstageable pressure ulcers achieved healing by the time of death (Level 5 study). Thus, while healing remains unlikely in individuals receiving palliative care, it should not be assumed that all ulcers in palliative care individuals will not heal.

1. **Set treatment goals consistent with the values and goals of the individual, while considering input from the individual's significant others. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
 - 1.1. **Assess the impact of the pressure ulcer on quality of life for the individual and his/her significant others. (Strength of Evidence = C; Strength of Recommendation = 👍)**
 - 1.2. **Set a goal to enhance quality of life, even if the pressure ulcer cannot be healed or treatment does not lead to closure/healing. (Strength of Evidence = C; Strength of Recommendation = 👍)**
 - 1.3. **Assess the individual initially and at any change in their condition to re-evaluate the plan of care. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These statements are based on expert opinion. In palliative care, primary pressure ulcer treatment goals include the management symptoms that impact on quality of life, including pain, wound exudate and malodor.

2. **Assess the pressure ulcer initially and with each dressing change, but at least weekly (unless death is imminent), and document findings. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

See the guideline section *Assessment of Pressure Ulcers and Monitoring of Healing* for general assessment information.

- 2.1. **Monitor the pressure ulcer in order to continue to meet the goals of comfort and reduction in wound pain, addressing wound symptoms that impact quality of life such as malodor and exudate. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

This statement is based on expert opinion. In palliative care, monitoring the wound is an important step toward providing comfort, reducing wound pain, and addressing symptoms such as malodor and exudate. In many cases, the pressure ulcer may worsen as death approaches and as the individual's condition worsens. As the physical condition of the individual deteriorates, less frequent ulcer assessment may assist in minimizing pain for the individual.

3. Control wound odor. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. In palliative care, a major focus of wound care is control of wound malodor as it contributes to improving quality of life. Wound odor results from bacterial overgrowth and necrotic tissue. Malodorous wounds are frequently polymicrobial, with both anaerobes and aerobes present. The presence of malodor from a pressure ulcer can be very disturbing to an individual, contributing to significant feelings of embarrassment and/or depression, desire for isolation, and poor quality of life.^{1, 9, 45-48}

Odor control includes approaches aimed at the cause of the odor as well as the environmental impact. The first approach includes wound cleansing; identification and management of infection and critical colonization; and debridement of necrotic tissue. Use of these approaches should be consistent with the individual's wishes. Use of odor-controlling dressings and other odor-controlling products may also be helpful.

3.1. Manage malodor through regular wound cleansing; assessment and management of infection; and debridement of devitalized tissue, with consideration to the individual's wishes and goals of care. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This statement is based on expert opinion. The *Wound Care: Cleansing, Wound Care: Debridement, and Wound Dressings for Treatment of Pressure Ulcers* sections of this guideline outline general recommendations on managing pressure ulcers. The *Assessment and Treatment of Infection and Biofilms* section of this guideline provides recommendations on assessing pressure ulcers for infection, and appropriate use of antimicrobials.

3.2. Consider use of topical metronidazole to effectively control pressure ulcer odor associated with anaerobic bacteria and protozoal infections. (Strength of Evidence = C; Strength of Recommendation = 👍)

Metronidazole is an antimicrobial agent effective against anaerobic bacteria^{1, 49} and protozoal infections such as *Trichomonas*. Topical metronidazole gel (0.75 to 0.80%) is frequently used directly on the wound once per day for 5 to 7 days, or more often as needed^{50, 51} and metronidazole tablets can be crushed and placed onto the ulcer bed.^{9, 52}

3.3. Consider use of charcoal or activated charcoal dressings to help control odor. (Strength of Evidence = C; Strength of Recommendation = 👍)

Charcoal-impregnated dressings have been found to minimize wound odor. Activated charcoal attracts and binds wound odor molecules.^{9, 48, 53}

3.4. Consider use of external odor absorbers or odor maskers for the room (e.g., activated charcoal, kitty litter, vinegar, vanilla, coffee beans, burning candle, and potpourri). (Strength of Evidence = C; Strength of Recommendation = 👍)

4. Manage the pressure ulcer and periwound area on a regular basis as consistent with the individual's wishes. (Strength of Evidence = C; Strength of Recommendation = 👍)

This statement is based on expert opinion. Regular treatment of the pressure ulcer is essential in any attempts to achieve complete healing, although this may not be possible in each individual receiving

palliative care. When wound closure is not possible, the management options outlined throughout this clinical guideline should be considered for their potential to promote comfort.

Pain Assessment and Management

Relief of pain is important in all aspects of wound care and requires careful assessment and treatment. This is especially important for individuals in palliative care with pressure ulcers, as a primary goal is to provide comfort and improve their quality of life. As such, the following suggestions may be helpful in achieving this goal.

1. **Do not under treat pain in individuals receiving palliative care. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

See the *Pain Assessment and Management* section of this guideline for recommendations on management of pressure ulcer related pain.

2. **Select a wound dressing that requires less frequent changing and is less likely to cause pain. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

See *Wound Dressings for Treatment of Pressure Ulcers* section of this guideline for general recommendations on wound dressing selection.

Resource Assessment

1. **Assess psychosocial resources initially and at routine periods thereafter (psychosocial consultation, social work, etc.). (Strength of Evidence = C; Strength of Recommendation = 👍)**
2. **Assess environmental resources (e.g., ventilation, electronic air filters, etc.) initially and at routine periods thereafter. (Strength of Evidence = C; Strength of Recommendation = 👍)**
3. **Educate the individual and his or her significant others regarding skin changes at end of life. (Strength of Evidence = C; Strength of Recommendation = 👍)**
4. **Validate that family care providers understand the goals and plan of care. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These statements are based on expert opinion. Environmental resources are not all well-defined and typically are not included in formal pressure ulcers risk assessment tools; however, the importance of environmental resources in both the development and healing of pressure ulcers is clinically relevant in palliative care.^{18, 54}

It is important that the individual and their family and caregivers are aware that as time of death approaches, the body's vital organs (including the skin) will begin to shut down. Pressure ulcers may develop, even though prevention strategies are in place.¹⁶

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PEDIATRIC INDIVIDUALS

Introduction

Pressure ulcers are a significant concern for the pediatric population. As discussed in the *Prevalence and Incidence of Pressure Ulcers* section of the guideline in more detail, pediatric pressure ulcer prevalence rates reported in the international literature since 2000 range from 0.47% to 75%, with the highest prevalence reported in children with chronic illness and those with medical devices. Pressure ulcer incidence rates of 0.29% to 27% have been reported in the recent literature.¹ Recognition of the risk of pressure ulcers in children is important, as lack of awareness on behalf of the health professional, and a perception that pressure ulcers are not a concern for this special population leads, caregivers to overlook the importance of assessment and prevention.²

The recommendations outlined in other sections of this guideline are generally appropriate for the prevention and treatment of pressure ulcers in pediatric populations. Of particular relevance to children is the guideline section *Medical Device related Pressure Ulcers*. An exception is the chapter *Nutrition in Prevention and Treatment*, which provides recommendations for nutritional intake for adult populations, based on research conducted in adults.

As part of this guideline update, a comprehensive search was conducted for pressure ulcer literature in pediatric populations published since January 2008. Literature published prior to this date may also support the recommendations in this section.

Pressure Ulcer Risk Assessment

An assessment of risk factors for pressure ulcers, followed by planning and implementation of early preventive interventions, is an integral component of patient care. Pressure ulcers in children cannot be underestimated nor presumed to be uncommon. Pressure ulcer risk assessment is an essential component of the admission process, not only to identify risk but also to ensure that effective preventive strategies are planned and implemented. Early recognition of risk factors is the precursor to planning preventive care.

- 1. Perform an age appropriate risk assessment that considers risk factors of specific concern for pediatric and neonate populations, including:**
 - activity and mobility levels,
 - body mass index and/or birth weight,
 - skin maturity,
 - ambient temperature and humidity,
 - nutritional indicators,
 - perfusion and oxygenation,
 - presence of an external device, and
 - duration of hospital stay. (Strength of Evidence = B; Strength of Recommendation = 👍👍)

The pediatric population is at risk of pressure ulcers due to inherent differences in their anatomical characteristics compared to adults. Children's body surface area proportions differ from those of adults, for instance they have a disproportionately larger head size as compared to the head-body proportions of an adult.^{2, 3} Not only does this influence their risk of pressure ulcers, but it also contributes to a difference in the anatomical sites most susceptible to skin and tissue breakdown.^{2, 3}

Fujii et al. (2010)⁴ conducted a prospective cohort study in seven neonatal intensive care units (NICUs) in Japan. Neonates (n = 81) included in the survey had a mean age of 32.5 weeks gestation and a mean birth weight of 1,745 grams. Daily clinical skin assessment identified that the cumulative pressure ulcer incidence was 16%, with 62% of pressure ulcers occurring in neonates of less than 33 weeks gestation.

Approximately 78% of the pressure ulcers were classified as Category/Stage II and the remainder were Category/Stage I.

In univariate analysis, factors found to be significantly associated with development of a pressure ulcer ($p < 0.05$) were low birth weight, skin texture, incubator temperature and humidity, the support surface, limited position changes and endotracheal (ET) intubation. The multivariate analysis found two significant factors that increased risk of pressure ulcers in neonates. Skin texture immaturity measured using the Dubowitz Neonatal Maturity Assessment Scale had an odds ratio (OR) of 7.6 (95% confidence interval [CI] 1.58 to 36.71, $p = 0.012$) and ET intubation had an OR of 4.0 (95% CI 1.04 to 15.42, $p = 0.047$)⁴ (Level 2 study).

Skin maturity is directly related to the neonate's age. At 23 to 24 weeks gestation, the stratum corneum is not developed, and by 30 weeks gestation it has only two to three cell layers. The skin appears as transparent, and is particularly fragile.³ Thus, the skin of younger infants provides an inadequate barrier and, as indicated in risk studies, is highly susceptible to breakdown.



Schindler et al. (2011)⁵ conducted a large retrospective database review in nine pediatric intensive care units (PICUs) in the US over a 22 month period ($n = 5,346$). The aggregate incidence of pressure ulcers was 10.2%, with 63% reported as Category/Stage I pressure ulcers, 32% Category/Stage II pressure ulcers and the remainder were Category/Stage III or IV pressure ulcers. A multivariate analysis identified a hospital stay of greater than three days (OR = 5.88, 95% CI 4.481 to 7.21, $p < 0.001$) and score on the Pediatric Index of Mortality scale (OR = 1.132, 95% CI 1.055 to 1.215, $p < 0.001$) to be significantly associated with an increased risk of pressure ulcers. In addition, four factors associated with an increased risk of pressure ulcers were related to the use of ventilation devices:

- bi-level positive airway pressure (BPAP) or continuous positive airway pressure (CPAP) (OR = 2.004, 95% CI 1.509 to 2.661, $p < 0.001$);
- mechanical ventilation (OR = 1.334, 95% CI 1.031 to 1.726, $p = 0.03$);
- high frequency oscillatory ventilation (OR = 2.057, 95% CI 1.208 to 5.134, $p = 0.01$); and
- extracorporeal membrane oxygenation OR 2.490 (95% CI 1.208 to 5.134, $p=0.01$) (Level 4 study).

In this study there was a wide pressure ulcer incidence range (0.8% to 17.5%) between different PICUs,⁵ suggesting that pressure ulcer management protocols in different units may have influenced the findings; however, this was not investigated in the study.

Anthony et al. (2010)⁶ conducted a cross-sectional study investigating validity of various pediatric risk assessment tools. The researchers recruited children with pressure ulcers ($n = 61$) and children without pressure ulcers ($n = 175$). Three pediatric risk assessment tools were administered to all the pediatric participants by nurses trained in the use of the scales. The logistic regression analysis for all three risk assessment tools identified that decreased mobility, and incontinence and/or moisture were significantly associated with presence of a pressure ulcer. Tissue perfusion, presence of pyrexia and low serum albumin were found to be significant for two of the risk assessment tools. The age of the pediatric population in this study was not reported. The risk assessment tools were applied after the development of the pressure ulcer for the 26% of the study participants with pressure ulcers (Level 3 study).

In a prevalence study conducted through retrospective review of records from 1,314 pediatric admissions to one US PICU over a three year period, Rana et al. (2009)⁷ established an increased rate of pressure ulcers in obese (body mass index [BMI] \geq the 95th percentile for their age) children compared to children of normal BMI (1% versus 0.2%, $p = 0.04$). The children's height and weight from which the BMI was calculated was documented on admission, prior to the the development of pressure ulcers. Comorbidities and other factors that may influence pressure ulcer risk were not reported in the study.

1.1. Consider children with medical devices to be at risk for pressure ulcers. (Strength of Evidence = B; Strength of Recommendation =  )

Medical device related pressure ulcers are also an important consideration in children. In a retrospective review of children (mean age 45 months \pm 8.7 months) who underwent a tracheostomy over a 15 month period in a US pediatric medical center (n = 65), Jaryszak et al. (2011)⁸ reported the rate of tracheostomy related pressure ulcers as 29.2%. Multivariate analysis found that the type of tracheostomy tube (p = 0.003) and a lower age (under 12 months versus over 12 months) were significant risk factors for a device related pressure ulcer (Level 5 study).

In a prospective cohort study conducted in seven NICUs (n = 81; mean age 32.5 weeks gestation), Fujii et al. (2010)⁴ reported that 86% of pressure ulcers were associated with CPAP or directional positive airway pressure (DPAP). A multivariate analysis showed an OR of 4.0 (95% CI 1.04 to 15.42, p = 0.047) for pressure ulcers in children undergoing ET intubation. In this study most of the neonates were extremely underweight, which also a factor associated with increased pressure ulcer risk (Level 2 study).

Schindler et al. (2011)⁵ conducted a multivariate analysis of risk factors for pressure ulcers from retrospective data collected in seven PICUs and trauma centers (n = 5,346). A number of medical devices were significantly associated with an increased risk of pressure ulcers including mechanical ventilation (OR = 1.334, 95% CI 1.031 to 1.726, p = 0.03); BPAP or CPAP (OR = 2.004, 95% CI 1.509 to 2.661, p < 0.001); high frequency oscillatory ventilation (OR = 2.057, 95% CI 1.208 to 5.134, p = 0.01) and extracorporeal membrane oxygenation (OR = 2.490, 95% CI 1.208 to 5.134, p = 0.01) (Level 4 study).

In a prospective point prevalence study conducted in children hospitalized for at least 24 hours (n = 412; aged 24 hours to 18 years) Schluer et al. (2012)⁹ reported that 40% of children with an external medical device were assessed as having a pressure ulcer related to the device.

2. **Consider using a reliable and valid pediatric pressure ulcer risk assessment tool to facilitate a structured assessment. (Strength of Evidence = C; Strength of Recommendation = 👍)**

This recommendation is based on expert opinion. Pressure ulcer risk assessment tools are often used to guide a structured approach to risk assessment. For further discussion on structured risk assessment, see the guideline section *Risk Factors and Risk Assessment*.

Recent studies have focused on the reliability of various pediatric risk assessment tools.^{6, 10-12} Willock et al. (2008)¹¹ demonstrated 100% agreement ($\kappa = 1.0$) on nine subscales and good agreement for the tenth subscale ($\kappa = 0.63$) of the Glamorgan scale when used by 15 nurse raters to assess 15 children with a low pressure ulcer risk (Level 3 study). Kottner et al. (2012)¹⁰ found good agreement (48%) between 27 nurses administering the Glamorgan scale to 30 children, but the scale had poor interrater reliability (intraclass coefficient [ICC] = 0.34, 95% CI 0.12 to 0.57). Findings were similar in a second study by the team.¹² The scale had poor differentiation between children, possible because of the overall low pressure ulcer risk of the sample (Level 2 study).

Assessment and Monitoring

1. **Engage the family or legal guardian involved in the individual's care when establishing goals of care. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
2. **Conduct and document a skin assessment at least daily and after procedures for changes related to pressure, friction, shear, moisture. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

These recommendations are based on expert opinion. Assess the skin at the time of admission to the health care facility (or at first visit for community settings) and at regular intervals (i.e., at least every 24 hours). In particular, assess skin over bony prominences. See the *Assessment of Pressure Ulcers and Monitoring of Healing* section of the guideline for recommendations related to skin assessment. The

Classification of Pressure Ulcers and International NPUAP/EPUAP Pressure Ulcer Classification System sections of the guideline outline staging of pressure ulcers.

2.1. Assess the skin on occiput for neonate and pediatric individuals. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This recommendation is based on expert opinion. Younger individuals are at higher risk of developing occipital pressure ulcers due to their comparatively larger head circumference compared with older children and adults.^{2,3}

2.2. Inspect the skin under and around medical devices at least twice daily for the signs of pressure related injury on the surrounding tissue. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This recommendation is based on expert opinion. Younger individuals are at high risk of developing pressure ulcers associated with medical devices.^{2,5,13} The guideline section on *Medical Device Related Pressure Ulcers* is of particular significance to pediatric individuals.

Nutritional Management

The recommendations in the *Nutrition in Pressure Ulcer Prevention and Treatment* section of the guideline have been developed based on evidence in adult populations and are generally not appropriate for pediatric individuals. There is a paucity of research on the most appropriate nutritional interventions for neonates and children with or at risk of pressure ulcers.

Neonates and children are at higher risk of nutritional deficiencies due to having an increased nutritional requirement per unit weight to meet normal growth needs, as well as having smaller appetites and dietary intake. Additionally, children at risk of or with a pressure ulcer for the most part have other severe acute or chronic comorbidities that influence both nutritional needs and the ability to meet these needs.¹⁴ Nutritional assessment; selection of the appropriate mode of feeding; frequent monitoring; strategies to promote adequate intake in an appealing manner; and, when required, nutritional supplements or nutritional support, are all important considerations in the promotion of wound healing in children.¹⁵

1. Conduct an age appropriate nutritional assessment for neonates and children. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

1.1. Regularly reassess the nutritional requirements of critically ill neonates and children who have, or are at risk of, a pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

These recommendations are based on expert opinion. A pediatrician, dietitian or other qualified health professional should conduct an age appropriate nutritional assessment to identify nutritional requirements for neonates and children with or at risk of pressure ulcers. The Braden Q scale (designed for use in pediatric individuals aged from 21 days to 8 years) includes a nutritional screening tool that considers the child's usual nutritional intake that may supplement the before mentioned assessment. Anthropometric measurements and growth charts can be used to determine if the child is developing within expected growth patterns;^{14, 15} however, consider the influence of edema and fluid shifts on measures made in critically ill children.¹⁴ Critically ill children should have their energy expenditure assessed regularly in order to determine appropriate energy needs. Consider that standard equations are often unreliable in estimating energy expenditure in children^{14, 16} because they are often derived from measurements in healthy children or adults.¹⁶ When direct measurement cannot be made, ensure that any energy expenditure equation that is used to estimate needs is both age and condition appropriate.¹⁶

2. **Develop an individualized nutrition care plan for neonates and children with, or at risk of, a pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍)**
3. **Ensure all neonates and children maintain adequate hydration. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**
4. **When oral intake is inadequate, consider age appropriate nutritional supplements for neonates and children who are at risk of a pressure ulcer and are identified as being at risk of malnutrition. (Strength of Evidence = C; Strength of Recommendation = 👍)**
5. **When oral intake is inadequate, consider age appropriate nutritional supplements for neonates and children who have an existing pressure ulcer and are identified as being at risk of malnutrition. (Strength of Evidence = C; Strength of Recommendation = 👍)**
6. **When oral intake is inadequate, consider enteral or parenteral nutritional support in neonates and children who are at risk of a pressure ulcer or have an existing pressure ulcer and who are also identified as being at risk of malnutrition. (Strength of Evidence= C; Strength of Recommendation = 👍)**

These recommendations are based on expert opinion and indirect evidence. Energy and protein intake should be determined in consideration of:

- requirements for normal growth and development;
- any nutritional deficiency;
- altered needs associated with critical illness or comorbidities; and
- needs associated with wound healing.¹⁵

A pediatrician, pediatric dietitian or other qualified health professional should be involved in planning an appropriate, individualized nutrition plan, and providing caregivers with strategies to promote nutritional intake.¹⁵ Energy needs should be individualized and determined with consideration to energy expenditure in order to avoid overfeeding or underfeeding. In a review of cohort studies conducted in critically ill children, the variability of metabolic state and thus the inappropriate nature of providing recommendations on specific intake goals was highlighted.¹⁴ The American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines for nutritional requirements for children who are critically ill also indicate that there is insufficient evidence to make specific recommendations on the macronutrient requirements for these children¹⁴ (indirect evidence).


Selection of Support Surfaces

1. **Select an age appropriate, high specification support surface for children at high risk of pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍)**

The efficacy and safety of using a support surface designed for an adult individual for preventing pressure ulcers in the pediatric population has not been investigated thoroughly. When selecting a pressure redistribution support surface for children, consideration should be given to the specific bony prominences most at risk.


García-Molina et al. (2012)¹⁷ compared the incidence of hospital acquired pressure ulcers in a cohort of children in intensive care who were placed on a continuous, reactive low pressure support surface compared with a standard mattress. The support surface consisted of a double air cell construction with three separate compartments for the head, body and trunk. Although the pressure differed between each section, it was consistent within each section (i.e., not an active support surface). The study mattress was available in two sizes, one for children weighing 500 g/1.1 lb to 6 kgs/13.2 lb (n = 4) and one for children above 6 kgs/13.2 lb (n = 26). Due to clinical condition, 63% of the participants did not receive any repositioning during their time on the study mattress. There was a significant decrease in facility-acquired pressure ulcers (not related to medical devices) associated with the study mattress

compared to a retrospective cohort that used a standard hospital mattress (3.3% versus 20%, 95% CI 0.08% to 17.2%, $p < 0.021$). The severity of the pressure ulcers that did develop was not reported. One third of the children who participated in the study had a pre-existing pressure ulcer on admission to the PICU, and of these, 66.6% had healed prior to their discharge from the PICU (Level 4 study).

1.1. Select a high specification support surface for premature infants and younger children to prevent occipital pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = )

Occipital pressure ulcers are a specific concern for younger pediatric individuals. For younger children, the head composes a greater percentage of the body surface area than in adults and the occiput is a primary pressure point for children in the supine position.^{3, 18} In a survey of seven NICUs, Fujii et al. (2010)⁴ reported that approximately 7% of reported pressure ulcers were in the occipital region. Schindler et al. (2011)⁵ supported these findings in their own survey of nine PICUs that reported 6% of pressure ulcers were occipital.

Turnage-Carrier et al. (2008)¹⁹ investigated the interface pressure at the occipital bony prominence in healthy premature (mean age 30.2 gestational weeks) infants who were in an open crib, feeding and gaining weight, had no history of pressure ulcers and were within one to three weeks of discharge ($n = 11$). Infants with head or neck abnormalities were excluded from the study. The infants were placed on five different support surfaces and interface pressure was measured under the occiput after five minutes. The infants were consecutively placed on a gel mattress, a gel pillow, a water pillow and a standard crib/cot mattress with 2.75 inch (7 cm) thick foam overlay and a standard (undefined) crib/cot mattress. A regular crib/cot blanket was placed over each support surface, except the gel pillow, which was fitted with its own disposable cover. Each of the four high specification support surfaces were associated with significantly lower interface pressure ($p < 0.001$) compared to a standard crib/cot mattress. The mattress with the foam overlay had the lowest interface pressure (31 mmHg versus 86.8 mmHg for the standard crib/cot mattress, $p < 0.001$). Development of pressure ulcers was not an outcome measure in this study (indirect evidence).

2. Ensure that the individual's height, weight and age are consistent with the manufacturer's recommendations when placing a pediatric individual on a low-air-loss bed or alternating pressure support surface. (Strength of Evidence = C; Strength of Recommendation = )

This recommendation is based on expert opinion. The manufacturer's weight recommendations for low-air-loss beds should be followed. Low-air-loss beds have pressure areas designed for adults. When children are placed on an adult bed, their head is frequently positioned in an area with pressures designed for an adult's trunk.²⁰

Alternating pressure support surfaces are designed to support the weight of an adult over a larger number air cells than will be required to support a child's surface area, resulting in inappropriate pressures. The child's smaller limbs can lodge between alternating air cells, and the sacrum region can rest between cells in the sitting position.²¹ This results in a need to more regularly reposition the child appropriately on the alternating pressure cells.²¹

Repositioning

The *Repositioning and Early Mobilization* section of the guideline outlines general recommendations on the frequency and principles for repositioning for prevention and treatment of pressure ulcers. In addition, the following recommendations should be considered for pediatric individuals.

1. Ensure that the heels are free of the surface of the bed. (Strength of Evidence = C; Strength of Recommendation = 👍)

This recommendation is based on expert opinion. Suspension of heels off the bed is particularly important in neonates and smaller children as it is difficult to redistribute pressure off the smaller surface area of pediatric heels, even with a high specification support surface.¹⁸ In their study measuring interface pressures, McLane et al. (2002)²⁰ found that mean perpendicular heel interface pressure was significantly higher than coccyx and occiput interface pressure for children aged from six to 16 years. Heel interface pressure was significantly lower when the foot was positioned on its side, due to the increase in surface area (indirect evidence). Floating the heels entirely free of the bed surface further reduces the risk of heel pressure ulcers.

2. Frequently reposition the head of neonates and infants when they are sedated and ventilated. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Pediatric individuals are at high risk of occipital pressure ulcers. Diligent repositioning of the neonate or infants head is of particular importance when the individual is sedated and is unable to reposition alone.

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INDIVIDUALS WITH SPINAL CORD INJURY

Introduction

Individuals with spinal cord injury (SCI) are at an increased risk of pressure ulcers due to immobility, decreased sensation and altered pathophysiology that predisposes the skin to breakdown.¹

The risk of pressure ulcers impacts individuals with SCI at every stage of their care. Ploumis et al. (2011)² found that receiving acute care in a SCI-specific facility at the time of injury significantly decreased the risk of having a pressure ulcer by the time the individual reached the rehabilitative stage of their care (12% versus 34% for individuals cared for in a non-SCI acute care facility, $p < 0.001$). While having a shorter length of stay in acute care reduces the risk of developing a pressure ulcer,^{2,3} if an individual does develop a pressure ulcer the length of stay in acute care becomes significantly longer, lengthening the recovery period.^{3,4}

Unlike many other individuals for whom pressure ulcers are no longer a risk following their discharge from a health care facility, individuals with SCI face a life-long risk that impacts their daily living. Up to 95% of individuals with SCI will experience a pressure ulcer at some stage during their life.¹ In a longitudinal study in which in-depth interviewing was conducted with 30 individuals with SCI in the US, Jackson et al. (2010)⁵ identified that the risk of pressure ulcers was perceived as a perpetual danger and individuals often faced tension between living a full life and avoiding situations that put them at higher risk of pressure ulcers. Ongoing awareness and motivation to prevent pressure ulcers was identified as essential by these individuals; however, they frequently reported barriers to accessing care, services, resources and support.

The recommendations included in other sections of the guideline are generally appropriate to individuals with SCI. This population-specific section of the guideline includes recommendations specific to, or of particular relevance for individuals with SCI.

Preventing Pressure Ulcers During the Acute Care Phase

1. **Transfer the individual off a spinal hardboard/backboard as soon as feasible after admission to an acute care facility in consultation with a qualified health professional. (Strength of Evidence = C; Strength of Recommendation = 👍)**



This recommendation is based on expert opinion. Health professionals with appropriate clinical expertise should review the individual as soon as possible after admission. Numerous early studies have investigated interface pressure related to hardboards; however no research has determined a safe duration of immobilization on a hardboard. In the event that the individual is awaiting transfer to another facility (e.g. a SCI-specialized facility) he or she should not be maintained on a hardboard while awaiting transfer. Padded boards, bracing and appropriate positioning may be used after review by the appropriate health professional.⁶

2. **Replace an extrication cervical collar with an acute care rigid collar as soon as feasible in consultation with a qualified health professional. (Strength of Evidence = C; Strength of Recommendation = 🗨️)**

This recommendation is based on expert opinion. Extrication cervical collars should be removed and replaced with acute care rigid collars as soon as feasible.^{7,8}

Seating Surfaces

The *Support Surfaces* section of the guideline outlines comprehensive recommendations on pressure redistribution support surfaces for the bed and chair to both prevent pressure ulcers and promote their healing. The majority of these recommendations are also appropriate for individuals with SCI. The recommendations below are those that are of specific significance to individuals with SCI.

- 1. Individualize the selection and periodic re-evaluation of a wheelchair/seating support surface and associated equipment for posture and pressure redistribution with consideration to:**
- **body size and configuration;**
 - **the effects of posture and deformity on pressure distribution; and**
 - **mobility and lifestyle needs. (Strength of Evidence = C; Strength of Recommendation =  )**



This recommendation is based on expert opinion. Use of a wheelchair is imperative for individuals with SCI. Selection of a chair that provides appropriate support and ability to tilt, should be based on an individual assessment that includes pressure mapping.^{1,9}

One study compared center of pressure displacement in individuals with SCI to that of healthy volunteers. The participants sat in a static position on a hard, backless chair with appropriate foot support while pressure mapping was performed. Center of pressure displacement was significantly lower in individuals with SCI than healthy volunteers ($p < 0.05$), indicating impaired dynamic sitting stability. There was no significant difference in center of pressure displacement between individuals with high or low thoracic SCI. Significant differences were noted in center of pressure displacements during forward leaning and backward leaning positioning for individuals with SCI who had a past history of pressure ulcers¹⁰ (indirect evidence). The individual's ability to weight shift in various seated positions should be assessed and considered in selection of an appropriate wheelchair/seating system.

The recommendations on repositioning in this section of the guideline discuss tilting and support requirements for a seating system. The *Support Surfaces* section of the guideline also includes comprehensive recommendations on the selection and maintenance of support surfaces (wheelchairs and pressure redistribution cushions) that are appropriate for individuals with SCI.

- 1.1. Refer individuals to a seating professional for evaluation. (Strength of Evidence = C; Strength of Recommendation = )**

This recommendation is based on expert opinion. Where available, seating clinics provide professional advice and education for individuals with SCI. Selection of an appropriate seating system is aided by a specialist health professional's advice and clinical knowledge, and access to interface pressure mapping and thermography to assess the individual's needs.^{1,9}

- 2. Select a pressure redistribution cushion that:**
- **provides contour, uniform pressure distribution, high immersion or offloading;**
 - **promotes adequate posture and stability;**
 - **permits air exchange to minimize temperature and moisture at the buttock interface; and**
 - **has a stretchable cover that fits loosely on the top cushion surface and is capable of conforming to the body contours (Strength of Evidence = C; Strength of Recommendation =  )**

This recommendation is based on expert opinion. As with a wheelchair/chair, the selection of a pressure redistribution cushion should be individualized and include pressure mapping results and assessment of the individual's posture and stability.⁹ No single cushion is appropriate for all individuals with SCI.⁹

Cushion construction achieves pressure redistribution by one of two basic methods: immersion/envelopment or redirection/off-loading. Envelopment is the capability of a support surface to deform around and encompass the contour of the body. Cushions that utilize envelopment must deflect and deform to immerse the buttocks in the material. Flat cushions must deflect more than contoured cushions. The anthropometrics of the pelvis require about 50mm (2 inches) of immersion for effective envelopment due to the inferior position of the ischial tuberosities (assuming there is no asymmetry in the pelvis). Cushions that redirect loads accomplish this via relief areas in the cushion surface.

In one study conducted in volunteers with SCI who had not had a recent pressure ulcer, interface pressure mapping was conducted for 15 minutes with a range of four different cushions. In this study, a

cushion constructed of firm foam and gel had the highest mean interface pressure. A cushion with dual compartments containing two chambers that simulated an ergonomic seating base had the lowest mean interface pressure. The variability in high specification pressure redistribution cushion performance with respect to interface pressure was highlighted¹¹ (indirect evidence).

A tight, non-stretch cover will adversely affect cushion performance. Covers that fit loosely on the top surface and those that are made from a stretch material are better-suited to let the cushion material deform as intended to allow immersion.

Evidence suggests that a rise in tissue temperature increases the susceptibility to pressure ulcers;^{12, 13} however, more research is required on the effectiveness in reducing pressure ulcers of pressure redistribution cushions that maintain the skin at lower temperatures.⁹

3. Assess other seating surfaces commonly used by the individual and minimize the risk they may pose to skin. (Strength of Evidence = C; Strength of Recommendation = 👍)

This recommendation is based on expert opinion. Other commonly used seating surfaces (e.g., commodes, toilets, shower bench, travel seats and recreational seating) should be reviewed to ensure they meet the individual's pressure redistribution needs (e.g., appropriate padding) and there is no specific risk to skin (e.g., from broken surfaces). All equipment should be periodically reassessed as the individual's posture and deformity, functional ability, comorbidities, preferences and needs change over time.¹

Additional Support Surface Recommendations For Individuals With Existing Pressure Ulcers

1. Seat individuals with pressure ulcers on a seating support surface that provides contour, uniform pressure distribution, and high immersion or offloading. (Strength of Evidence = B; Strength of Recommendation = 👍👍)

Rosenthal et al. (2003)¹⁴ studied healing rates of Category/Stage III and IV pressure ulcers in individuals with mobility limitations (including SCI) in a randomized clinical trial (RCT) comparing a reactive polyurethane foam overlay (n = 38), a low-air-loss bed (n = 38), and a reactive total contact wheelchair cushion designed to sustain interface pressures at the ischial tuberosities below capillary pressure (n = 38). Participants randomized to receive the pressure redistribution support cushion sat out of bed in a wheelchair with individualized tilt for one session daily, for a maximum of four hours. The type of bed mattress on their beds was not reported. Participants randomized to receive the overlay or the low-air-loss bed were on complete bed rest. Participants in all study groups were repositioned every two hours when in bed. At four weeks, approximately 10% of the participants in the overlay group had deteriorating pressure ulcers and were withdrawn from the study (their data were also excluded from analysis). The participants in the seating cushion group had significant improvement in their pressure ulcers compared to the other two groups, as assessed using the Pressure Sore Status Score (PSSS). Over the six month follow up period, time to total healing was significantly faster for participants in the seating cushion group than in the participants in the two groups confined to bed (cushion: 3.33 ± 0.12 months versus low-air-loss 4.38 ± 0.14 months versus overlay 4.55 ± 0.22 months, p < 0.001) (Level 1 study). These results were obtained under conditions of precise seating surface prescriptions; similar results may not be possible in settings without an experienced seating specialist.

2. Use alternating pressure seating devices judiciously for individuals with existing pressure ulcers. Weigh the benefits of off-loading against the potential for shear based on the construction and operation of the cushion. (Strength of Evidence = C; Strength of Recommendation = 👍)

Alternating pressure seating devices have been used in many clinical settings¹⁵. A study by Burns et al. (1999)¹⁶ concluded that there is a similar relief in pressure over the ischial tuberosities between a dynamic cushion during the low-pressure phase compared with a tilt-in-space wheelchair with a

conventional cushion. Individual responses to the high-pressure phase may vary. Because the potential for shear across alternating cells exists, the effect on the individual should be carefully observed.

Wheelchairs equipped with an individually adjusted automated seat providing cyclic pressure relief using a protocol of ten minutes normal sitting and ten minutes offloaded sitting may enhance pressure ulcer closure and decrease wound area. A RCT (n = 44) conducted by Makhsous et al. (2009)¹⁷ found significantly more improvement in pressure ulcer area closure and Pressure Ulcer Scale for Healing (PUSH) score in individuals using an automated, cyclic relief seat compared with individuals in a standard wheelchair who performed arm push-ups for pressure relief every 20 or 30 minutes. The group using the cyclic pressure relief seating system achieved a mean $45 \pm 21\%$ improvement in mean pressure ulcer surface area compared with $10.2 \pm 34.8\%$ improvement in the control group ($p < 0.001$). As the study did not address possible differences between groups in preventive measures provided when the individuals were not seated, differences in wound care/dressings, and pressure ulcers size at baseline, it was not possible to recommend an adjusted automated seat above a standard wheelchair with a manual pressure relief regimen (Level 2 study).

Repositioning and Mobility

The *Repositioning and Early Mobilization* section of the guideline outlines comprehensive recommendations on positioning individuals to both prevent pressure ulcers and promote their healing. The majority of these recommendations are also appropriate for individuals with SCI. The recommendations below are those that are of specific significance to individuals with SCI.

1. Maintain proper positioning and postural control. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

1.1. Provide adequate seat tilt to prevent sliding forward in the wheelchair/chair, and adjust footrests and armrests to maintain proper posture and pressure redistribution. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

These recommendations are based on expert opinion. The ischia bear intense pressure when the individual is seated. Pressure remains unrelieved when the individual is paralyzed because small involuntary movements that restore blood flow to the tissues are absent. Seat tilt can be used to reduce the interface pressure at the ischial tuberosities, which are particularly vulnerable to damage from pressure in the seated position. A repeated measures study¹⁸ systematically measured the relative reduction in interface pressure at the ischial tuberosities and sacrum through 10° increments of tilt in a manual wheelchair for individuals with SCI. A reduction in sacral pressure did not occur until a 30° tilt. A minimum tilt of 30° is needed to achieve a clinically important reduction in pressure at the ischial tuberosities (indirect evidence).

1.2. Avoid the use of elevating leg rests if the individual has inadequate hamstring length. (Strength of Evidence = C; Strength of Recommendation = 👍)

The hamstring muscle crosses the knee and hip joint. If the hamstring length is inadequate and elevating leg rests are used, the pelvis will be pulled into a sacral sitting posture, causing increased pressure on the coccyx/sacrum.

2. Use variable-position seating (tilt-in-space, recline, and standing) in manual or power wheelchairs to redistribute load off of the seat surface. (Strength of Evidence = C; Strength of Recommendation = 👍)

2.1. Tilt the wheelchair before reclining. (Strength of Evidence = C; Strength of Recommendation = 👍)

These recommendations are based on expert opinion and indirect evidence. Dynamic weight shifting uses assistive technologies to relieve pressure when the individual has limited ability to

effectively perform intentional weight shifting due to paralysis. The study by Giesbrecht et al. (2011)¹⁸ found that a minimal tilt of 30° is required to attain a clinically important reduction in interface pressure at the ischial tuberosities (indirect evidence).

Dynamic weight shifting should be used frequently throughout the day and an individualized plan based on pressure mapping, functional ability, skin response to pressure relief and lifestyle should be developed with the individual.¹ Because extensor tone increases in the recline position the chair should be tilted to prevent sliding.¹

3. Encourage the individual to reposition regularly while in bed and seated. (Strength of Evidence = C; Strength of Recommendation = 👍)

3.1. Provide appropriate assistive devices to promote bed and seated mobility. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

These recommendations are based on expert opinion. Most individuals with SCI can actively participate in pressure redistribution through repositioning, unless they have comorbidities that interfere with bed and seating mobility. Bed mobility (e.g., rolling, side-lying, prone positioning and recumbent positioning) and seated weight redistribution (shifting, pelvic and leg repositioning) should be taught during initial rehabilitation and then retrained and reinforced during ongoing admissions and contacts with health professionals.¹

Individuals should be encouraged to lift rather than drag their bodies during repositioning and transfers. Appropriate assistive devices (e.g., sliding boards, bed rails or trapeze bars) assist in minimizing shear and friction during repositioning.¹

4. Establish pressure relief schedules that prescribe the frequency and duration of weight shifts. (Strength of Evidence = C; Strength of Recommendation = 👍)

4.1. Teach individuals to do ‘pressure relief lifts’ or other pressure relieving maneuvers as appropriate. (Strength of Evidence = C; Strength of Recommendation = 👍)

4.2. Identify effective pressure relief methods and educate individuals in performance of methods consistent with the ability of the individual. (Strength of Evidence = C; Strength of Recommendation = 👍)

These recommendations are based on expert opinion. Other appropriate weight shifting techniques may include leaning forward, leg lifts, side leaning and, when assessed by an appropriate health professional and with assistive devices, standing.¹

The duration and frequency of weight-shift strategies should be individualized. For example, active individuals with SCI perform frequent unintentional weight-shifting throughout the day (e.g., while propelling a wheelchair) and require intentional weight-shifting maneuvers less frequently than those who engage in less activity. Assessment of the individual’s daily routine and regular inspection of the skin should guide the frequency and intensity of intentional weight shifts.¹

Additional Repositioning Recommendations For Individuals With Existing Pressure Ulcers

1. Weigh the risks and benefits of supported sitting versus bed rest against benefits to both physical and emotional health. (Strength of Evidence = C; Strength of Recommendation = 👍)

1.1. Consider periods of bed rest to promote ischial and sacral ulcer healing. (Strength of Evidence = C; Strength of Recommendation = 👍)

This recommendation is based on expert opinion. Sitting time may need to be restricted when ulcers are present on sitting surfaces. Ideally, ischial ulcers should heal in an environment where the ulcers are free of pressure and other mechanical stress.

Although total bed rest may create a pressure-free wound environment; this approach to pressure ulcer healing comes with potential complications including but not limited to:


- muscle wasting and joint contracture;
- loss of bone density;
- deconditioning,
- respiratory complications,
- malnourishment,
- psychological harm,
- social isolation,
- financial challenges for the individual and his/her family.¹⁹

Balancing physical, social, psychological and financial needs of the individual against the need for total offloading (i.e., total bed rest) creates a challenging dilemma for the individual and the professional.

In one RCT reported above, Rosenthal et al. (2003)¹⁴ found that individuals with limited mobility had significantly faster healing of Category/Stage III and IV pressure ulcers when they sat out of bed in a tilted wheelchair with a reactive pressure redistribution cushion for up to four hours daily compared to individuals who were confined to bed rest on either a foam overlay or low-air-loss bed (Level 1 study). However, these results were obtained under conditions of precise seating surface prescriptions in carefully selected individuals; similar results may not be possible in settings without an experienced seating specialist and the availability of appropriate pressure redistribution cushions.

One clinical guideline for the management of pressure ulcers in individuals with SCI highlights that the availability of advanced pressure redistribution support surfaces, ability to offload with various tilting positions and the use of pressure relief lifts provides many individuals with SCI options for supported sitting. However, where modern support surfaces or tilt options are not available, and for some individuals (e.g., those for whom a seated position would disrupt wound healing), bed rest is indicated.¹

Total bed rest for up to six weeks (at the discretion of the surgeon) is recommended for individuals who have undergone flap reconstruction surgery (see the *Surgery for Pressure Ulcers* section of the guideline).

1.2. Develop a schedule for progressive sitting according to the individual's tolerance and pressure ulcer response in conjunction with a seating professional. (Strength of Evidence = C; Strength of Recommendation = )

This recommendation is based on expert opinion. Sitting is important to reducing the hazards of immobility, facilitating eating and breathing, and promoting rehabilitation. While sitting is important for overall health, every effort should be made to avoid or minimize pressure on the ulcer. Sitting applies pressure to the sacrum when the individual does not sit erect (i.e., slouches). When individuals sit erect, pressure is applied to the ischia.

A seating professional should be involved in assessing the individual, selecting an individualized pressure redistribution support cushion and in the development of an appropriate individualized supported sitting plan.

A supported sitting plan should be individualized to the individual's tolerance, and skin should be assessed after each sitting period. Sitting times can be increased or decreased based on the

improvement or deterioration of the ulcer. Periodic shifting, tilting forward, or lift-offs while sitting may facilitate some reperfusion.

Houghton et al. (2013)¹ provide one example of a plan for progressive wheelchair/chair sitting (with a pressure redistribution support cushion). Developed for individuals with SCI following flap reconstruction surgery (to commence at approximately three weeks after surgery or when open incisional areas show signs of healing) it could also be appropriate for adapting to the needs of individuals recovering from a pressure ulcer. The plan includes:

- Commence with sitting on the edge of bed for 10 minutes twice daily (seating days 1 to 3).
- If no new skin breakdown occurs, transfer to a wheelchair for 5 to 10 minutes twice daily and increase the time spent in a wheelchair by 5 minutes each day (seating days 4 to 7).
- If no new skin breakdown occurs, transfer to a wheelchair for 30 minutes twice daily and increase the time spent in a wheelchair by 10 minutes each day to a maximum of 60 minutes twice daily (seating days 8 to 10).
- If no new skin breakdown occurs, increase the time spent in a wheelchair by 15 minutes each day aiming for a minimum of 4 hours twice daily.

2. Avoid seating an individual with an ischial ulcer in a fully erect posture in chair or bed. (Strength of Evidence = C; Strength of Recommendation = 🙅🙅)

The ischia bear intense pressure when the individual is seated. A repeated measures study by Giesbrecht et al. (2011)¹⁸ indicated that a minimum tilt of 30° is needed to achieve a clinically important reduction in pressure at the ischial tuberosities (indirect evidence).

Electrical Stimulation for Preventing Pressure Ulcers

There is emerging evidence that electrical stimulation induces intermittent tetanic muscle contractions and reduces the risk of pressure ulcer development in at-risk body parts, especially in individuals with SCI. Electrical stimulation (ES) may decrease tissue atrophy by increasing muscle mass, improving blood flow and tissue oxygenation. The periodic muscle contractions redistribute the loading and stiffness of the deformed soft tissues. This method appears practical in daily life and is well tolerated.^{20, 21}

1. Consider the use of electrical stimulation for anatomical locations at risk of pressure ulcer development in individuals with spinal cord injury. (Strength of Evidence = C; Strength of Recommendation = 🙅)

This recommendation is based on indirect evidence and expert opinion. Two clinical experiments, one moderate quality comparative study²¹ and one low quality cross-over RCT²⁰ investigated the effect of ES-induced activation of the gluteal and hamstring muscles on the sitting pressure distribution in individuals with SCI. Participants received ES in their own daily-use wheelchair while sitting pressure was measured. During an ES procedure the subjects wore special ES-shorts with built-in electrodes over the gluteus and hamstrings. Biphasic pulsed current (BPC) was applied with a frequency of 50 pps to induce tetanic muscle contractions. The current amplitude ranged from 70 to 115 mA (average 94 ± 12.5 mA) in the study by Smit et al. (2012)²¹ and from 70 to 80 mA in the study by Janssen et al. (2010).²⁰

In the study by Janssen et al. (2010)²⁰ five participants completed two 3-hour sessions of ES, both consisting of 3 minutes of stimulation (all muscles simultaneously activated) followed by 17 minutes of rest. Intervention A consisted of a 3 minute stimulation cycle, with 1-second on: 1-second off. Intervention B consisted of a 3 minute stimulation cycle with 1-second on and 4-seconds off. Peak and mean pressure under the tuber areas were calculated throughout the ES session. All participants (n = 10) in the study by Smit et al. (2012)²¹ completed two 1-hour protocols of ES, both consisting of 3 minutes of stimulation and a 17 minute rest period. A cycle of 1-second stimulation and 4-seconds off was performed within each 3 minutes of ES. During the first one hour of ES the gluteal muscles were stimulated, and during the next hour of ES gluteal and hamstrings muscles were stimulated. In both studies the difference between mean pressure under the tuber area and surrounding sensors was

calculated. This pressure gradient may indicate shear forces; a high pressure gradient is associated with high shear forces within the tissue, increasing the risk of a pressure ulcer developing (indirect evidence).

Janssen et al. (2010)²⁰ reported that for both interventions A and B the peak pressure decreased significantly ($p < 0.05$) during the three hour stimulation periods. The pressure gradient tended ($p < 0.1$) to decrease for both intervention protocols indicating an improved pressure distribution. Within the three minute stimulation, muscle fatigue apparently occurred only during intervention A, not during intervention B. As no differences in maximal pressure reductions were found between the first, second and third hours of stimulation sessions, the authors concluded that 17 minutes rest between the 3 minute stimulation cycles in intervention A (1-second on:1-second off) and in intervention B (1-second on:4-seconds off) was sufficient to obtain the full muscle rest. Smit et al. (2012)²¹ found both gluteal and gluteal-plus-hamstring muscle activation gave significant interface pressure relief, but activation of gluteal-plus-hamstring muscles gave significantly more mean pressure relief than activation of gluteal muscles only. Pressure gradient reduced significantly (49.3%, $p = 0.01$) only after stimulation of gluteal-plus-hamstring muscles (indirect evidence).

The authors of the above studies concluded that ES-induced tetanic contractions of the gluteal and hamstring muscles in sitting individuals with SCI causes a temporary decrease in peak sitting pressure under the tuber area and an improved pressure distribution. ES procedures should be applied for 1 to 3 hours/day with a 50 pps current in an intermittent cycle: 3 min of stimulation (including 1-second on:1-second off or 1-second on:4-seconds off) and 17 minutes of rest. However, it must be observed that a protocol with longer rest periods (1-second on:4-seconds off) results in larger pressure reductions and less muscle fatigue²⁰ so it seems a more effective stimulation method. Stimulation of gluteal and hamstring muscles appears to be more effective than stimulating only the gluteal muscles²¹ (indirect evidence).

Education and the Individual's Involvement in Care

In addition to the recommendations below, the *Patient Consumers and Their Caregivers* section of the guideline provides additional recommendations specifically for individuals with SCI.

1. Promote and facilitate self-management for individuals with SCI. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

In one qualitative study, individuals with SCI ($n = 16$) identified the need for empowerment, education and approaches to coordination of social supports as priorities for ongoing management of their condition. Promotion of self-management through facilitating access to appropriate equipment and services within the community, providing education and support for managing pressure ulcer risk in the home environment and ensuring that the individual and his or her caregivers have a realistic perception of the risk of pressure ulcers were all highlighted as significant themes in the interviews²² (indirect evidence). These findings were supported by a second qualitative study in which the need to advocate for one's self and to balance prevention and lifestyle concerns was highlighted by individuals with SCI ($n = 19$) as important for ongoing care. In this study, providing information on wound care clinics, community-based resources and consumer support groups; facilitating access to medical help when required; and providing education were all considered valuable²³ (indirect evidence).

2. Provide individuals with SCI and their caregivers with structured and ongoing education on prevention and treatment of pressure ulcers at a level appropriate to their education background. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

In a qualitative study reported above, Schubart et al. (2008)²² found that individuals with SCI have inconsistent knowledge of pressure ulcer risk, lack of knowledge of how to adapt the home environment, and limited knowledge of how to access health care services after discharge. Individuals reported receiving limited and often fear-oriented education. These findings highlight the importance of

developing and delivering structured and ongoing education on pressure ulcer prevention and treatment to individuals with SCI.

Providing education during long hospitalization (three to six months) has been shown to improve knowledge of pressure ulcers and self-care ability.²⁴ In a prospective cohort study that followed 214 individuals with SCI admitted to German hospitals within a four year period, mean knowledge levels of pressure ulcer prevention and treatment improved significantly at discharge compared to baseline ($p < 0.001$). Knowledge levels did decrease over the 30 month follow up period, but remained higher than the pre-hospitalization level. Participants identified health professionals as their primary source of education. In the post-discharge period two of every five participants used the internet to supplement information received from health professionals. Only about half of the individuals in this study considered the inpatient education program important, and patient support groups were not considered to be a source of education²⁴ (indirect evidence).

In one study conducted in a trauma hospital and outpatient department, individuals with SCI ($n = 16$) experienced improvements in their knowledge after participating in a e-learning program²⁵ (indirect evidence). Schubart (2012)²⁶ also reported significant improvement in knowledge levels ($p < 0.005$) following delivery of an e-learning package aimed at individuals with SCI ($n = 15$) that had at least a high school level of education (indirect evidence).

In a psychometric study, Gélis et al. (2011)²⁷ reported that the revised Skin Management Needs Assessment Checklist (SMNAC) is a valid and reliable tool for assessing the knowledge and skills of individuals with SCI regarding preventive practices and regular skin assessment. The tool, which has been translated languages other than English, is a self-administered, 12-item checklist that can be used to identify knowledge gaps (indirect evidence).

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IMPLEMENTING THE GUIDELINE

The following sections of the guideline address issues relating to implementation of the guideline in health care organizations. This includes implementation strategy, health professional education, recommendations specifically for patient consumers and their caregivers, and quality indicators for monitoring guideline implementation

FACILITATORS, BARRIERS AND IMPLEMENTATION STRATEGY

Introduction


Research associated with pressure ulcer prevention and treatment strategies has grown exponentially over the past two decades, as has the commitment by policy developers, educators and health care administrators to implement these strategies into evidence-based practice. Despite these advances, there is a gap between what is known and what is actually done to prevent and treat pressure ulcers.

Knowledge transfer has recently become an industry in itself, with its own body of research, nomenclature and a peer reviewed journal (*Implementation Science*), all aimed at finding effective strategies for translating research evidence into practice. As yet, this translational science is in its infancy, especially in the area of successfully implementing guidelines pertaining to pressure ulcer prevention and treatment. Consequently, opportunities exist for well-designed studies to shed light on the most effective ways to support the uptake of evidence in this area. Synthesizing information from the implementation literature will assist in these efforts by illuminating strategies that have contributed to successful guideline implementation.

This section of the pressure ulcer guideline has been introduced in the 2014 guideline revision and only the most current research published between 1st January 2008 and 31st December 2012 was reviewed. Literature published prior to 2008 may also support the recommendations. As outlined in *Appendix 1: Guideline Methodology*, additional inclusion criteria were applied to quality improvement literature. For inclusion, research was required to report pressure ulcer incidence or facility-acquired pressure ulcer rates as an outcome measure, with at least three outcome measurement time points and/or demonstrated sustainability of the intervention and positive outcomes. Interventions were required to be reported in sufficient detail that replication would be possible.

The recommendations in this section address actions that can be implemented at the organization level or professional level in order to facilitate the introduction of and adherence to clinical guidelines that outline optimal strategies for the prevention and treatment of pressure ulcers. These strategies are based on barriers and facilitators to implementation of pressure ulcer guidelines that have been described in literature. Implementation at an organizational level is a multi-level construct that refers to strategies with a focus on the shared readiness of organizational members to implement a change and the shared belief in their collective capability to do so. At a professional level, implementation focuses on strategies that relate to individual professionals. A sound underpinning at both the organizational and professional level is essential for effective introduction of a clinical guideline, as well as for ongoing promotion of an organizational culture of adherence to best practice recommendations. The guideline section *Implementing the Guideline: Health Professional Education* provides recommendations on education as a specific facilitator of guideline implementation and quality care.

Recommendations

- 1. Assess barriers and facilitators for guideline implementation at professional and organizational levels before implementing a pressure ulcer prevention initiative within the organization. (Strength of Evidence = C; Strength of Recommendation = )**

This recommendation is based on expert opinion. Before developing a quality improvement plan, identify strengths that can be capitalized on and weaknesses requiring address. Barriers and facilitators

for guideline implementation are specific to the organization; therefore assessment at a local level is required in order to develop an implementation plan that meets the facility's needs.

The recent research identified knowledge and attitudes of health professionals, availability and quality of equipment, and staffing characteristics as factors that influence the successful implementation of pressure ulcer prevention and treatment strategies. Be aware that other barriers may be present and require address, and the facility may have other strengths that will assist in guideline implementation.

1.1. Assess knowledge and attitudes of professional staff regularly using validated assessment tools. (Strength of Evidence = C; Strength of Recommendation = 👍)

Assessment of health professionals' knowledge and attitudes related to pressure ulcer prevention and management identifies potential barriers to mitigate or facilitators to enhance when introducing a quality improvement initiative. In a randomized controlled trial (RCT) Beekman et al. (2013)¹ reported that assessing the knowledge and attitudes of health professionals provides information that can assist in the development of organization-specific interventions that improve the quality of pressure ulcer preventive care. The researchers used a validated pressure ulcer knowledge assessment tool and a tool designed to assess attitudes toward pressure ulcer prevention prior to implementing a pressure ulcer prevention program in eleven long term aged care facilities. The assessments were used to identify knowledge gaps, and to inform the development of interactive education interventions and strategies to support decision making in preventive care (Level 1 study).

In a study conducted in four intensive care units (ICUs) Strand et al. (2010)² assessed nurses' attitudes toward, and knowledge about pressure ulcer prevention. The researchers reported that nurses with higher levels of education were more likely to disagree with a statement that they have more interest in other aspects of care than in pressure ulcer prevention ($p = 0.009$) and were more likely to identify that individuals in the ICU have an increased risk for pressure ulcers ($p = 0.014$). Over one third (38%) of the nurse participants identified staff knowledge as a facilitator to pressure ulcer prevention (indirect evidence).

The *Implementing the Guideline: Health Professional Education* section of the guideline details comprehensive recommendations on training and education.

1.2. At an organizational level, assess the availability, quality and standards for use of available equipment for the prevention and treatment of pressure ulcers. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Multiple studies^{1, 3-5} indicated that evaluation of equipment availability and standardization of preventive measures have good potential to improve the quality of pressure ulcer preventive care. Beekman et al. (2013)¹ included an assessment of the availability and quality of pressure ulcer preventive resources as part of a multi-faceted implementation approach that was associated with a reduction in pressure ulcer prevalence in aged care facilities over three months (7.1% versus 14.6%) (Level 1 study). In a quasi-experimental study, Tippet (2009)⁵ included an evaluation of the support surfaces available within an aged care facility as part of a prevention program that reported sustained reduction in pressure ulcer prevalence over four years (Level 4 study). In other pressure ulcer prevention initiatives, multi-faceted interventions have included changing (e.g., increasing, upgrading or replacing) the equipment available within the facility.^{3, 4, 6}

1.3. At an organizational level, review availability of and access to support surfaces and establish protocols for procurement that ensure timely access for individuals at risk of, or with an existing pressure ulcer. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

This recommendation is based on expert opinion. Access to support surfaces may be limited out of regular business hours (e.g., if the facility uses rental/contract equipment). Organizations should review access to support surfaces and develop written guidelines and decision processes

that identify the fastest way to procure support surfaces when a need for them is identified out of regular business hours (e.g. on holidays, nights and weekends).

- 1.4. At an organizational level, review and select medical devices available in the facility based on the devices' ability to induce the least degree of damage from the forces of pressure and/or shear. (Strength of evidence = C; Strength of Recommendation = 👍👍)**

Institutions, with the input of the wound care professional, should provide medical devices that will minimize skin damage. This may include selection of softer, more flexible devices. In one large (n = 6,103) quality improvement study conducted in a US trauma center, pressure ulcers associated with endotracheal (ET) tubes were reduced with an institutional practice change in the ET tube securement device⁷ (Level 4 study).

Boesch et al. (2012)⁸ investigated a multifaceted intervention to reduce tracheostomy related pressure ulcers in 834 pediatric individuals. Interventions included the introduction of a hydrophilic foam dressing, in addition to the incorporation of a moisture and pressure free device interface and an extended tracheostomy tube. Significant reductions in tracheostomy related pressure ulcer rate (p = 0.007) and in the number of days with an existing tracheostomy related pressure ulcer (p < 0.0001) were associated with the introduction of the extended tracheostomy tube (Level 4 study).



- 1.5. Assess staffing characteristics (e.g. nursing care hours, qualifications of staff) and staff cohesion at an organizational level. (Strength of evidence = C; Strength of Recommendation = 👍)**

In a well-conducted cross-sectional study, Pekkarinen et al. (2008)⁹ used a validated nursing survey to assess the relationships between pressure ulcer prevalence and staff perspectives on time pressures and management decisions. Sixty-six facilities in Finland (n = 724 nurses) participated in the research. The researchers reported a significant association (p = 0.05) between increase in pressure ulcer prevalence and the nurses' ranking of time pressure within their unit. The study found no significant association between the perception of unfair management and pressure ulcer prevalence (p = 0.259). Konetzka et al. (2009)¹⁰ used an online survey to assess staffing characteristics in US aged care facilities (n = 1,366 facilities), including skills mix and number of registered nurse (RN) hours per resident per day. After adjusting for resident clinical conditions and facility level controls (e.g. Medicare), there was a significant decrease in pressure ulcer prevalence associated with increased available daily RN hours per resident (p < 0.05), but not with skills mix (p > 0.05) (Level 3 study). Hart et al. (2011)¹¹ assessed staffing characteristics in five US hospitals (n = 26 units/wards), and also reported a significant relationship between pressure ulcer prevalence and RN hours per patient per day (r = -0.525, p < 0.05) and total nursing care hours per patient (r = -0.485, p < 0.05) (Level 3 study). In a retrospective cohort study, Horn (2008)¹² found similar results, and reported a trend for decreasing pressure ulcer development associated with each additional ten minutes per day of direct care provided by an RN to the resident.


- 2. Conduct regular evaluation of organizational performance in pressure ulcer prevention and treatment and provide this information as feedback to the stakeholders. (Strength of evidence = C; Strength of Recommendation = 👍👍)**

- 2.1. Use appropriate quality indicators to monitor pressure ulcer prevention and treatment. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**



A large range of quality indicators, many of which related to local accreditation processes, are used to monitor pressure ulcer care. The *Implementing the Guideline: Quality Indicators* section of this guideline details a set of quality indicators that can be used to audit organizational performance. The quality indicators presented in that section of the guideline are specifically designed to audit implementation of the recommendations within this guideline.

2.2. Conduct regular monitoring of facility-acquired pressure ulcer rates as part of pressure ulcer prevention and treatment initiatives. (Strength of evidence = C; Strength of Recommendation =  )



Many studies reported monitoring facility-acquired pressure ulcer rates as a method for evaluating the success of preventive programs.^{1, 4, 8, 13-17}

2.3. Introduce an electronic system to report and track pressure ulcer prevalence. (Strength of evidence = C; Strength of Recommendation = )

A well conducted RCT demonstrated sustained reduction in Category/Stage I to IV pressure ulcers (7.1% versus 14.6%, $p < 0.05$) associated with a multi-faceted intervention that included a computerized monitoring system. The system allowed staff to enter the results of clinical audits and to undertake computer analysis and presentation of the facility's ongoing progress (Level I study).¹ Ballard et al. (2008)¹⁴ reported a successful pressure ulcer reduction bundle that included introduction of an electronic database to track weekly facility-acquired pressure ulcer rates in ICUs and a medical ward (Level 4 study).

2.4. Regularly inform staff members, patients and caregivers of pressure ulcer rates. (Strength of evidence = C; Strength of Recommendation =  )

Successful facility-wide pressure ulcer prevention programs have included regular (e.g., weekly and/or monthly) reporting of pressure ulcer occurrence to stakeholders through newsletters, posters, flyers or computer-generated reports.^{4, 8, 13-17}

3. Develop a structured, tailored and multi-faceted approach to overcome barriers and enhance facilitators for protocol implementation. (Strength of evidence = B; Strength of Recommendation =  )

Research conducted at a national level has shown that a facility's ongoing involvement in quality improvement initiatives (including evidence-based guideline introduction and implementation, regular prevalence surveys and annual national surveys) is associated with significant reductions in pressure ulcer prevalence within the facility. Lahmann et al. (2010)¹⁸ reported non-significant reductions in facility-acquired pressure ulcer prevalence for aged care facilities ($n = 60$ facilities with 7,377 residents) in Germany that were repeatedly involved in national level quality improvement surveys. In the same study, participation in two annual national pressure ulcer quality improvement surveys by acute care hospitals ($n = 82$ with 28,102 individuals) was reported to be associated with a drop in Category/Stage II or greater facility-acquired pressure ulcer rates of 3.9% ($p = ns$). Facilities that were involved for a three year period experienced a significant decrease from a mean 10.2% to 5.2% for facility-acquired Category/Stage II to IV pressure ulcers. Results of this study suggest that ongoing involvement in quality improvement initiatives helps facilities achieve significant and sustainable reductions in pressure ulcer prevalence (Level 4 study).

Evidence from the studies outlined below provides support for the introduction of a multi-faceted 'intervention bundle' that addresses the specific needs of the facility for improving pressure ulcer prevention and treatment. Most successful approaches incorporated strategies at both the professional and organization level, suggesting that adopting a multi-faceted approach is an effective strategy.

3.1. Consider optimizing work procedures at a professional level through the introduction of:

- **tailored staff education,**
- **role models or designated wound care “champions”,**
- **nurse-led quality improvement programs, and**
- **cues to perform pressure ulcer prevention. (Strength of evidence = C; Strength of Recommendation = Ⓢ)**

The current evidence base to guide selection of strategies to be used for successful facilitation of pressure ulcer prevention guideline implementation is weak. Overall, there is some indicative evidence advocating for use of tailored and multi-faceted approaches to increase the well-informed involvement of health professionals and to minimize resistance to change arising from the implementation of a pressure ulcer prevention protocol.^{1, 4, 6, 13, 15, 17, 19-24} Selection of specific interventions to include in a multi-faceted pressure ulcer prevention program should be based on the thorough evaluation of the barriers and facilitators specific to the organization.¹

Tailored health professional education was included in the majority of pressure ulcer reduction programs reviewed for this guideline. Education was delivered using classroom based^{4, 13, 15, 23, 25}, bed-side,^{17, 20} online,^{1, 3, 8, 26} written²⁰ or unspecified^{5, 27} models. Recommendations on health professional education are discussed in detail in the *Implementing the Guideline: Health Professional Education* section of the guideline.

One of the primary interventions included in the multi-faceted pressure ulcer prevention program investigated by Revello et al. (2012)²³ was the introduction of a “wound care champion” who took a lead role in staff education informally on the unit. Skills or credentials of the wound care champion were not reported in the study, and the intervention was limited by high turn-over of staff in the position, as well as the limited hours the wound care champion was available on the unit (i.e. the wound care champion did not cover all work shifts). Regardless, the researchers reported a reduction of pressure ulcer prevalence from 16.7% prior to the introduction of the program to 0% at 18 months (Level 4 study). Bales et al. (2011)¹³ included introduction of a National Database of Nursing Quality Indicators® (NDNQI) trained “wound champion” in their multi-faceted intervention, in conjunction with a Certified Wound Ostomy Continence Nurse (CWOCN) and mandatory staff education. A sustained reduction in facility-acquired pressure ulcer prevalence was reported over seven years (12% to 0%)^{4, 13} (Level 4 study). Ackerman (2011)¹⁹ reported including a skin care nurse, who conducted visual assessments to detect skin breakdown (Level 4 study).

Kelleher et al. (2012)²⁰ introduced a pressure ulcer reduction intervention to a critical care unit that was described as a nurse-led quality improvement program. The intervention primarily involved bed-side rounds using a “question format” and regular nurse meetings that focused on individual-specific issues. The researchers reported a reduction in facility-acquired pressure ulcers from a high of 26.7% to a high of 6.3% over three years. However, the introduction of specialty pressure redistribution support surfaces in the timeframe of the study is likely to have significantly influenced the reported reduction in pressure ulcers (Level 4 study).

Cues to remind staff members to perform pressure ulcer prevention are used as components of many multi-faceted prevention programs. The literature reports use of various different cues including a visual ‘turn clock’;¹⁷ stickers to notify physicians of individuals with risk of skin breakdown;¹⁹ musical tune to cue repositioning;^{4, 13} pocket-sized education resources;²⁰ and daily reminders to use documentation systems.^{1, 15}

- 3.2. Consider optimizing work procedures at an organizational level through the introduction of:**
- **an awareness campaign,**
 - **standardized documentation,**
 - **standardized repositioning regimens (where the individual's needs will be met),**
 - **multidisciplinary meetings, and**
 - **on-site consultations. (Strength of evidence = C; Strength of Recommendation = ⤴)**

Organization level support is a key component of pressure ulcer prevention programs. The vast majority of successful pressure ulcer prevention programs reported in the literature included interventions implemented at an organizational level to support professional level initiatives.

Bales et al. (2009)⁴ introduced an awareness initiative called “Zero HAPU Campaign” at an organizational level that was sustained over more than four years (reduction in pressure ulcer prevalence from 12% to 0%). At an organizational level the awareness campaign included flyers and posters, and financial incentives to health professionals^{4, 13} (Level 4 study). In the pressure ulcer prevention program reported by Baldelli et al. (2008)¹⁷ ongoing awareness of pressure ulcer reduction was maintained through regular feedback (e.g. via posters) to health professionals about pressure ulcer prevalence and incidence rates (Level 4 study).

Standardized documentation systems have been included in numerous multi-faceted prevention programs. In a multi-center study conducted in 11 long term aged care facilities, Horn et al. (2010)¹⁶ introduced a standardized, computer documentation system that incorporated weekly automated electronic reports on completeness of records and identified individuals at high risk of pressure ulcer. Ongoing use of the standardized computer system to document pressure ulcer prevention and treatment was associated with a sustained 62% decrease in prevalence of facility-acquired pressure ulcers (Level 4 study). McNerney (2008)⁶ incorporated an automated referral to the CWOCN into a computer documentation system to promote timely review of individuals documented to be at high pressure ulcer risk (Level 4 study). Other studies have incorporated standardized documentation of pressure ulcer risk and skin assessment,^{14, 19, 28} pressure ulcer treatment,^{6, 28} and electronic medical records^{6, 28} into successful multi-faceted pressure ulcer prevention programs.

Rantz et al. (2009)²¹ reported on an intervention in which onsite consultation with a postgraduate gerontology nurse was used to drive a quality improvement plan that included pressure ulcer reduction. At risk long term care facilities in the US (those assessed at a national level of having poor quality indicators; n = 60) that received access to the nurse consultant reported a 22% reduction in pressure ulcer prevalence after one year, compared with a 3% increase in at risk facilities that did not subscribe to the intervention (n = 32). The onsite consultation was supported by email and telephone contact, as well as opportunities for facility staff to participate in interdisciplinary local facility meetings (Level 3 study).

Multidisciplinary meetings conducted between health professionals at four local facilities were the primary intervention in a pressure ulcer reduction program reported by Thomas (2008)²⁴. Regular monthly meetings that included education and development of standardized procedures were associated with a reduction in facility-acquired pressure ulcers from 53% to 12% over 16 months (Level 4 study). Multi-faceted interventions associated with reductions in pressure ulcer prevalence have included interdisciplinary collaboration between the nurse care team and dietitians for individuals with Category/Stage III and IV pressure ulcers¹⁹ and multidisciplinary leadership teams⁵ (Level 4 studies).

There is some indicative evidence that the introduction of standardized repositioning regimens that are supported by cues for health professionals to ensure implementation can be used successfully in multi-faceted pressure ulcer reduction programs (Level 4 studies).^{4, 13, 14, 17} Such regimens can be implemented for those individuals whose needs would be met by two or four hourly repositioning schedules.

4. Consider developing a computerized algorithm to assist clinicians in their selection of appropriate care strategies and equipment for treating pressure ulcers. (Strength of evidence = C; Strength of Recommendation = ⤴)

In a RCT Beeckman et al. (2013)¹ evaluated the effectiveness of an electronic system to support the decision making of health professionals developing individual-specific pressure ulcer prevention programs. The electronic system was part of a bundle of initiatives introduced in six long term care facilities. There was a significant reduction in Category/Stage I to IV pressure ulcers compared to the control facilities that received only a hard copy of a pressure ulcer prevention guideline (7.1% versus 14.6%, $p < 0.05$) (Level 1 study). Asimus et al. (2011)³ reported a sustained reduction in facility-acquired pressure ulcer rates (reduction from 23.4% to 8.0% over two years) associated with a pressure ulcer reduction program that included a computerized algorithm to assist clinicians in selection of appropriate preventive equipment. In this study, which was conducted in an Australian hospital, prescription of appropriate pressure ulcer preventive equipment for at risk individuals increased from 44% in year one to 90.9% in year three (Level 4 study).

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HEALTH PROFESSIONAL EDUCATION


Introduction

Non-adherence to pressure ulcer guidelines is a frequently reported concern. Many barriers may influence adherence to a guideline. Negative attitudes and lack of knowledge are expected to be common barriers to using guidelines in clinical practice. An attitude is an inclination to think positively or negatively about a person, situation, circumstance or object.¹ Knowledge is a familiarity with someone or something, which can include facts, information, descriptions, or skills acquired through experience or education. It can refer to the theoretical or practical understanding of a subject. Multiple studies have been published about the effectiveness of educational interventions on nurses' knowledge,²⁻⁶ the development and validation of assessment tools,^{7, 8} and the relationship between knowledge and behaviour in clinical practice.⁹⁻¹³ An association between knowledge and pressure ulcer incidence and/or prevalence outcomes has been made in only one small scale study (n = 52) with a quasi-experimental design.²

In general, there are mixed findings from descriptive studies that assessed existing knowledge levels of health professionals (primarily nurses) in regards to pressure ulcer prevention and treatment. Reported knowledge scores range from low (less than 50% of items correct) to high (more than 80% of items correct).¹⁴⁻²¹ Comparing study results is not possible because many different instruments have been used to conduct knowledge assessments. Furthermore, methodological limitations (e.g., selection bias, the use of non-validated knowledge assessment tools, and single site data collection) are common.

This section of the guideline has been introduced for the 2014 guideline revision and only the most current research published between 1st January 2008 and 31st December 2012 was reviewed. Literature published prior to 2008 could also support the recommendations. As outlined in *Appendix 1: Guideline Methodology*, additional inclusion criteria were applied to quality improvement and health education literature. For inclusion, research was required to report at least three outcome measurement time points and/or demonstrate sustainability of the intervention and positive outcomes. Interventions were required to be reported in sufficient detail that replication would be possible.

Recommendations

- 1. Assess knowledge and attitudes of professional staff regularly using reliable and valid assessment tools appropriate to the clinical setting. (Strength of Evidence = C; Strength of Recommendation = )**

Assessment of health professionals' knowledge and attitudes related to pressure ulcer prevention and management identifies potential barriers and facilitators for quality improvement initiatives. In a randomized controlled trial (RCT), Beeckman et al. (2013)²² reported that assessing the knowledge and attitudes of staff members provides information that can assist in the development of organization-specific interventions that improve the quality of pressure ulcer preventive care. The researchers used a validated pressure ulcer knowledge assessment tool and a tool designed to assess attitudes toward pressure ulcer prevention prior to implementing a pressure ulcer prevention program in eleven long term aged care facilities. The assessments were used to identify knowledge gaps, and to inform the development of interactive education interventions and strategies to support decision making in preventive care (Level 1 study).

One commonly used knowledge assessment scale, the Pieper Pressure Ulcer Knowledge Test (PPUKT), was developed in 1995. More recently, two studies have focused on the development and validation of tools to assess nurses' knowledge⁸ and attitudes.⁷ These studies produced respectively the Pressure Ulcer Knowledge Assessment Tool (PUKAT) and the Attitude towards Pressure Ulcer Prevention tool (APuP). Knowledge and attitudes scores using both instruments were found to be valid and reliable to assess pressure ulcer knowledge and attitudes.

2. Develop an education policy for pressure ulcer prevention and treatment at an organizational level. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

In a small pretest/post-test study conducted in four units in one long term care facility, Thomas (2012)⁵ found that implementing an education program that focused on risk assessment, prevention, pressure redistribution devices, other treatment options and documentation had a significant effect on knowledge ($p < 0.001$) and documentation performance ($p < 0.001$). In a smaller study ($n = 52$), Kwong et al. (2011)² found significant increase in knowledge ($p = 0.001$) and skills ($p = 0.001$) and a significant decrease in pressure ulcer incidence (2.5% at baseline versus 0.8% at 12 weeks) and prevalence (9% at baseline versus 2.5% at 12 weeks) after implementing a pressure ulcer prevention program that included clinical skills and an evidence-based treatment protocol (Level 4 study).

3. Provide regular evidence-based pressure ulcer prevention and treatment education. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

3.1. Evaluate learning outcomes before and after implementing an education program. (Strength of Evidence = C; Strength of Recommendation = 👍)

Cox et al. (2011)³ used a pretest/post-test study ($n = 60$) to compare face to face or didactic classroom teaching (one hour session conducted by a wound ostomy continence nurse [WOCN]) with computer-based learning for the retention of pressure ulcer knowledge. The results indicated that increased knowledge of pressure ulcer treatment was sustained over a six month period, with greater loss of knowledge in the first three months following education for those participating in computer-based learning. A study by Tweed et al. (2008)⁴ that included 62 nurses in a teaching hospital in New Zealand also found that knowledge improved for a short period after implementation of a structured education session. However, improvements in knowledge were not sustained five months following education delivery. Similar results were found in pretest/post-test studies by Thomas (2012)⁵ and Kwong et al. (2011)². Beeckman et al. (2008)⁶ found that the level of interrater agreement significantly increased when participants were asked to classify photographs of pressure ulcer following an e-learning program (35% versus 70%, $p < 0.001$). However, this positive effect had decreased significantly by three months following training (70% versus 62.5%, $p = 0.003$).

4. Tailor training and education on pressure ulcer prevention and treatment to both the needs of members of the healthcare team as well as the organization. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

The health professional's educational background^{15, 18, 20} has a significant association with his or her level of knowledge regarding pressure ulcer treatment. According to Beeckman et al. (2008)⁶ and Demarré et al. (2012)¹³, the health professional's knowledge level and professional responsibilities should be considered when designing and delivering education (content and didactic approach).

5. Utilize interactive and innovative learning in the design and implementation of a pressure ulcer prevention and treatment education program (Strength of Evidence = C; Strength of Recommendation = 👍)

Limited rigorous research into education delivery methods has been published. A range of strategies including computer-based learning^{6, 10-12}, small group teaching sessions,⁴ skills training² and blended learning³ are all reported to be valid alternatives to didactic classroom teaching. Interactive teaching sessions should have clearly defined learning objectives.^{5, 6}

Cox et al. (2011)³ concluded that computer-based learning is a viable option and has greater flexibility compared to didactic methods. In their small study (convenience sample, $n = 92$), an increased level of knowledge regarding pressure ulcer treatment was sustained over six months, with greater loss of

knowledge in the first three months following education. Beeckman et al. (2008)⁶ came to similar conclusions regarding the effectiveness of e-learning.

6. Consider incorporating the following components into the pressure ulcer prevention and treatment educational/training program:

- **etiology and risk factors for pressure ulcers;**
- **classification of pressure ulcers;**
- **differential diagnosis;**
- **risk assessment;**
- **skin assessment;**
- **documentation of risk assessment and a preventive care plan;**
- **selection and use of pressure redistribution support surfaces;**
- **repositioning, including manual handling and use of equipment;**
- **nutrition;**
- **the importance of an interprofessional approach; and**
- **education of the individual and his or her informal caregivers. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Educational programs reported in the literature vary in terms of their content, although the recommended list of topics has been incorporated into the majority of programs.^{2, 4-6, 10-12} Education should be informed by current evidence-based guidelines.

6.1. Educate health professionals on how to conduct an accurate and reliable risk assessment. (Strength of Evidence = C; Strength of Recommendation = 👍)

Education and clinical skills training has been shown to increase the reliability of risk assessment. In the seminal study by Bergstrom et al. (1987)²³, the reliability of risk assessment using the Braden scale was assessed among nurses with different qualification and levels of experience. The greatest degree of agreement was reported when assessments were undertaken by nursing staff with higher qualifications. A number of before/after studies indicate that education programs lead to an improvement in the reliability of risk assessment.^{11, 24} In a RCT, Hayes et al. (1994)²⁴ measured the effects of a teaching intervention on hospital nursing staff members' knowledge scores. The experimental group (n = 48) received a 40 minute teaching intervention that included information on the risk, assessment, and treatment of pressure ulcers. The control group (n = 54) received a 25 minute video presentation on general aspects of skin care for hospitalized individuals. The experimental group had a significantly higher overall knowledge score (p < 0.0001) and also a significantly higher score on each of three subcategories: risk (p < 0.0001), assessment (p < 0.01), and treatment (p < 0.0001) (indirect evidence).

Magnan et al. (2008)¹¹ evaluated the effect of a web-based Braden scale training program on the reliability and precision of pressure ulcer risk assessments made by registered nurses working in acute care settings. Five hundred Braden scale risk assessments were made on 102 individuals in acute care. Assessments were also made by registered nurses at three medical centers where the Braden scale was in regular daily use or was new to the setting. In the overall group, the proportion of reliable of risk assessments increased after the training (65% versus 62%), but this was not significant (p = 0.594). However, new users of the scale made reliable assessments 84% of the time and significantly improved the precision of their assessment (p = 0.005). The reliability and precision of Braden Scale risk assessments made by its regular users was unaffected by training (p = 0.12) (indirect evidence).

6.2. Educate health professionals in the use of the International NPUAP/EPUAP Pressure Ulcer Classification System. (Strength of Evidence = B; Strength of Recommendation = 👍👍)

Knowledge of normal anatomy at common pressure ulcer sites will help the health professional to differentiate tissue types from anatomical structures in healing wounds (e.g., differentiating slough from a tendon) and more accurately classify the Category/Stage of a pressure ulcer. Recognition of tissue types often requires training beyond basic professional programs.

Data indicate that training, whether it is accomplished by use of photographs and lectures or electronic learning, improves accuracy of pressure ulcer identification.^{6, 25} The use of photographs was found to be a reliable method of learning classification of ulcers. When photographs are combined with other assessment findings (such as descriptions and history taking), the ability of registered nurses without specialized training in wound care to accurately identify the wound improved to the level of specialty trained wound nurses.²⁶ The ideal number of photographs per type of ulcer has not been studied. In the papers reviewed, the numbers of photographs used ranged from three²⁷ to 120.²⁸ Hart et al. (2006)²⁶ used 17 photographs and Defloor and colleagues^{29, 30} used 56 photographs^{29, 30} (indirect evidence).

6.3. Educate health professionals in differentiating pressure ulcers from other types of wounds. (Strength of Evidence = C; Strength of Recommendation =)

Open wounds from various etiologies may appear similar; however, the treatment of a pressure ulcer (or other wound) begins with comprehension of its etiology. Hart et al. (2006)²⁶ reported on a study of the accuracy of nurses' assessments of pressure ulcers and other wound types. The most difficult aspect of the classification concerned the etiologies of other ulcers (e.g., neuropathic, venous, arterial, incontinence-associated dermatitis). Defloor and colleagues^{29, 31} have also reported that accuracy and reliability is low for nurses attempting to distinguish incontinence-associated dermatitis or moisture lesions from Category/Stage II pressure ulcers.

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PATIENT CONSUMERS AND THEIR CAREGIVERS

Introduction

Pressure ulcers are negatively associated with all domains of health related quality of life (HRQoL) in older adults.¹⁻⁶ The four domains of HRQoL considered in these studies were physical, psychological, social, and spiritual. No data from the literature reviewed for this guideline addressed the impact of pressure ulcers on younger adults' HRQoL.

When compared with adults without pressure ulcers, those with pressure ulcers have:

- poorer physical functioning (physical domain);^{1,2}
- lower levels of autonomy, security and spiritual wellbeing (spiritual domain);
- greater levels of depression (psychological domain);¹⁻³ and
- impaired social roles (social domain).²

Decreased physical function was shown to persist after pressure ulcers healed in one study.¹ Also, pain was worse for those with pressure ulcers in one pilot study.²

Because these studies look at associations, cause cannot be inferred. For example, it is not known whether the decline in physical functioning occurs before, after or at the same time as the pressure ulcer. We *cannot* say pressure ulcers are the cause of decreased physical function or that decreased physical function *causes* pressure ulcers. This relationship is true of each of the reported pressure ulcer associations i.e., physical function, less autonomy, decreased security, disrupted spiritual wellbeing, and impaired social role. Thus, it would be prudent to maintain maximal function in all HRQoL domains (i.e., physical, psychological, social and spiritual).

The patient consumer has an important role in pressure ulcer prevention. Knowledge of pressure ulcers and their prevention is important, and requires a special emphasis in those at high risk.

A simplified version of this section, written in basic English, is available from the guideline website (<http://www.internationalguideline.com>) for use as a patient consumer education resource.

Recommendations for Individuals With, or at High Risk of Pressure Ulcers

1. **Obtain information about pressure ulcers and their prevention as part of your routine care (Strength of evidence = C; Strength of Recommendation = 👍👍)**

Community dwelling individuals, as well as those with traumatic injury, lack general information about pressure ulcers.⁷⁻¹¹ Knowledge was increased with education provided by health professionals, printed materials, e-learning packages, and internet resources.⁷⁻¹¹

- 1.1 **Seek information from your health care team to address your individual pressure ulcer prevention and treatment needs. (Strength of Evidence = C); Strength of Recommendation = 👍)**

- 1.2 **Read printed material and use e-learning materials to enhance your knowledge of pressure ulcers and pressure ulcer prevention. (Strength of Evidence = C; Strength of Recommendation = 👍)**

- 1.3 **Use internet sources recommended by health professionals to provide current information about pressure ulcers and their prevention. (Strength of Evidence = C; Strength of Recommendation = 👍)**

2. **Work with the health care team to develop your individualized pressure ulcer prevention and management plan. (Strength of Evidence = C; Strength of Recommendation = 👍👍)**

Understanding what pressure ulcers are and what is known about their causes provides the basis for developing a plan to meet your own needs.^{7,8} An individualized health care plan requires an appreciation of other diseases or injuries that affect your overall health status, especially your ability to move, as well as knowledge of pressure ulcer prevention and management.^{2, 3, 12}

2.1. Seek information on how to prevent and treat pressure ulcers, including information on positioning in bed and chair, support surfaces, activity, and nutrition. (Strength of Evidence = C; Strength of Recommendation = 👍)

2.2. Work with your health care team to establish a pressure redistribution schedule including frequency and duration of weight shifts, using pressure relief methods that are consistent with your ability. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

Use 'pressure relief lifts' or other pressure relieving or redistributing maneuvers as appropriate.

2.3. Use variable position seating (tilt-in-space, recline, and standing) in manual or power wheelchairs to redistribute load off of the seat surface. (Strength of Evidence = C; Strength of Recommendation = 👍👍)

2.4. Use a bed and chair surface that is compatible with your care setting. (Strength of Evidence = C; Strength of Recommendation = 👍)

It is important that you participate in the selection of a support surface if it is to be used in your home. Structural considerations should be given to the delivery and setup of the surface/bed, taking into account such variables as hallways, width of doors, and access to electrical power. If the support surface is electrical, emergency plans should be reviewed with you and/or your caregiver and should include options in the event of power failure. Patients and their caregivers should follow the supplier's instructions regarding maintenance schedules, care and use of the support surface. To prevent falls, electrical cords should be kept away from transfer/walk areas. Support surface controllers/pumps should not be blocked by pillows, bedding, blankets, or clothing. The obstructed motor may overheat and fail to operate. Similar considerations apply to all care settings.

2.5. Evaluate the functionality of your support surfaces daily. (Strength of Evidence = C; Strength of Recommendation = 👍)

Any support surface can fail. Bedside caregivers must confirm that the support surface provides its intended function in the event of power failure or 'bottoming out'. Powered air-filled support surfaces may be over-inflated temporarily to provide a stable surface for care; however, the pressure redistribution mode should be resumed when care is completed. Ongoing function of the support surface can be accomplished by application of contractual support surface performance verification conducted by the manufacturer, or by professional staff trained in the use of standard recognized test methods.^{13, 14}

2.6. Consider your overall health status and how prevention and treatment of pressure ulcers contribute to it (e.g. activity and mobility, nutrition, and other diseases or injuries that affect your overall wellbeing). (Strength of evidence = C; Strength of Recommendation = 👍)

3. Identify concerns that you have about how to cope with having a pressure ulcer (Strength of evidence = C; Strength of Recommendation = 👍👍)

A qualitative study with a small sample of participants with pressure ulcers identified coping concerns of individuals that included: treatment and wound management; treatment burden; communication difficulties; ability to cope with functional limitations; poor support networks; and other health problems and co-morbidities.¹⁵ The researchers concluded that these factors all contribute to pressure ulcer HRQoL as well as interact with each other, resulting in a complex interaction between HRQoL and

contributory factors. A variety of available resources are shown to be helpful to patient consumers by providing advice on coping with pressure ulcers (e.g., suggested respite provided by family/friends) and treatment of pressure ulcers (e.g., home health care nurse advice on efficient storage and application of dressings).^{7-9, 11, 12}

- 3.1. Consider concerns in all aspects of wellbeing (physical, psychological, social, and spiritual) and their interaction. (Strength of evidence = C; Strength of Recommendation = 👍)**
- 3.2. Determine if there are gaps in your knowledge and/or ability to address your concerns. (Strength of evidence = C; Strength of Recommendation = 👍)**
- 3.3. Mobilize resources (health professionals, family, support groups, and community resources) to enhance your ability to cope with having a pressure ulcer. (Strength of evidence = C; Strength of Recommendation = 👍)**

Additional Recommendations for Individuals with Spinal Cord Injury

- 1. Ensure that you have knowledge of pressure ulcer prevention and self-care. (Strength of evidence = C; Strength of Recommendation = 👍👍)**

Individuals with spinal cord injury (SCI) are at high risk of pressure ulcer development throughout life. Education of individuals during long hospitalization (three to six months) improved their knowledge of pressure ulcers and self-care ability.¹¹ While knowledge decreased over the 30-month follow up period, it remained higher than the pre-hospitalization level. Participants identified health professionals as their primary source of education, and support groups were not considered a source of education. The internet supplemented information from health professionals for two of every five individuals in the post-discharge period. Only about half of the participants considered the inpatient education program to be important.¹¹

- 2. Consider seeking e-learning opportunities to increase your pressure ulcer knowledge. (Strength of evidence = C; Strength of Recommendation = 👍)**

Knowledge of pressure ulcer staging, prevention, and support services for individuals with SCI improved with an e-learning program designed and provided by health professionals in two poor quality studies with small samples.^{7, 9} Participants in one of these studies rated the utility, impact, and effectiveness of the e-learning package highly.⁹

E-learning and internet resources designed and/or recommended by health professionals are more likely to contain reputable information. The internet provides opportunity to access a wide range of health information; however, much of this information is inaccurate or incomplete. Using recommended websites, for example those maintained by government and health consumer groups, and discussing the information you access with your health care team increases the reliability of health education.

- 3. Empower yourself with knowledge about pressure ulcer risk factors and prevention; how to alter your home environment for care; and how to access care through the health system. (Strength of evidence = C; Strength of Recommendation = 👍👍)**

Interview data from a qualitative study showed that individuals with SCI had inconsistent knowledge of pressure ulcer risk; received limited and fear-oriented education; have a lack of knowledge of how to adapt homes to implement pressure ulcer prevention; and display limited knowledge of how to access health care services after discharge.¹⁰ Priorities for care identified by participants in this poor quality study included knowledge of lifelong risk, need for empowerment, need for strategies for care that can be modified as risk increases, and approaches to coordinate social support for themselves, the family, and paid caregivers.¹⁰ Another qualitative study emphasized early pressure ulcer recognition and detection, potential pressure ulcer severity and early treatment of those at risk as important

considerations for individuals with SCI.¹⁶ The study also addressed the need to advocate for one's self and to balance prevention and lifestyle concerns. Furthermore, information on wound care clinics and consumer support groups were identified as valuable ongoing community-based resources.¹⁶

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QUALITY INDICATORS FOR THIS GUIDELINE

Introduction

The quality indicators presented in this section of the guideline are intended to assist health care organizations to implement and monitor the strategies recommended in this clinical guideline for the prevention and treatment of pressure ulcers. The quality indicators have been developed to reflect the recommendations and current best practice outlined in this clinical guideline. The indicators are not intended to be prescriptive, or to replace other quality indicators in common use. Health care organizations that choose to use these guideline-specific quality indicators may use them in isolation or in addition to other local, national or international quality indicators.

Continuous quality improvement is a process by which health care organizations ensure systematic and intentional improvement of services to their consumers. Clinical guidelines are developed to improve quality of care through promotion of the most effective and safe interventions for managing clinical conditions. They provide recommendations on care that the clinician and health care organization can use to deliver quality care, in conjunction with clinical judgement and the consumer's personal wishes.¹

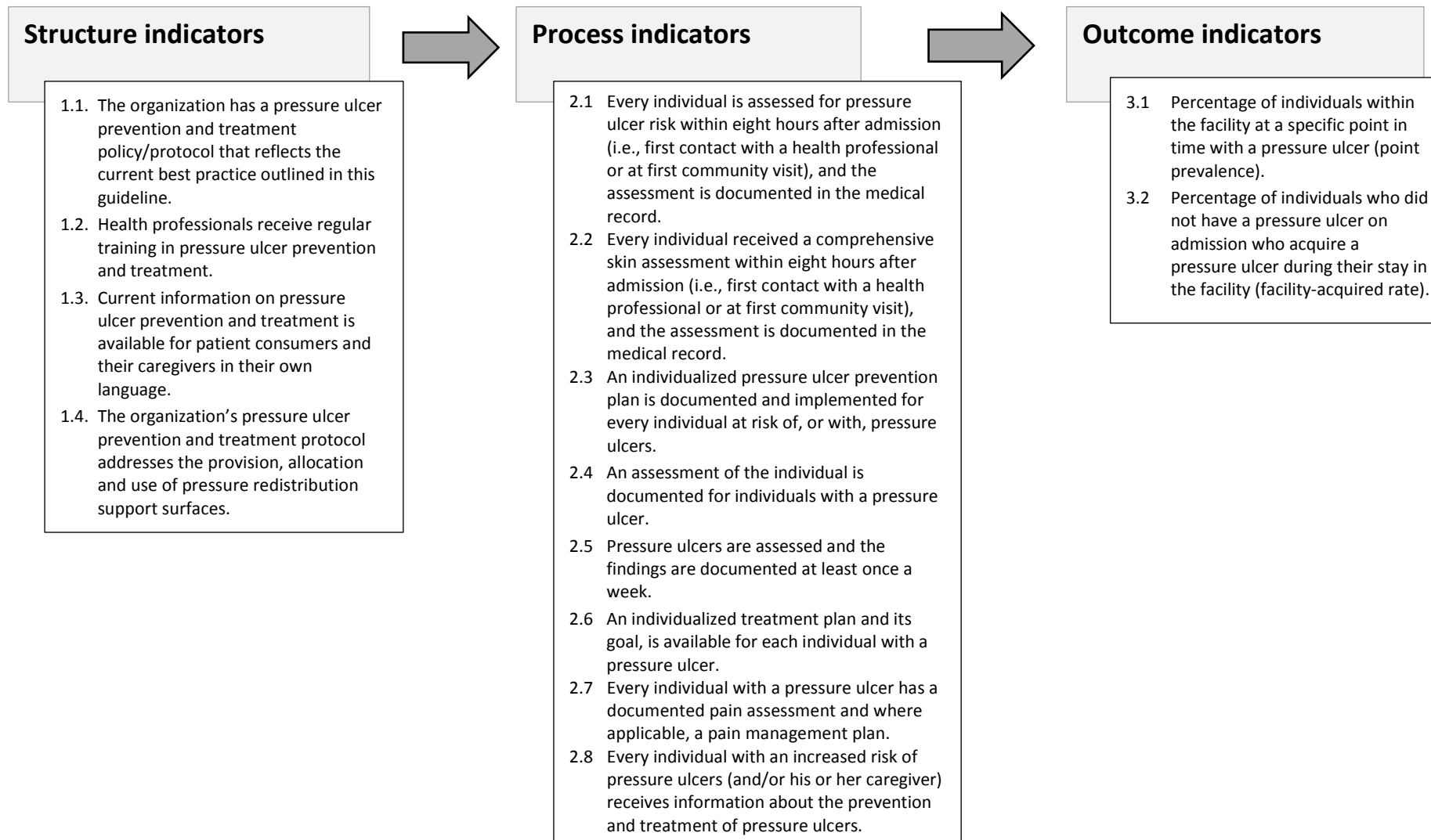
To gain insight into whether the quality of care being delivered reflects the best practice outlined in this clinical guideline and effectively addresses the individual's care needs, some form of evaluation is required. Quality indicators are developed as a measure of care to monitor quality and initiate future improvements.

Quality indicators

One way in which quality indicators can be distinguished is as internal or external indicators. Internal quality indicators are used by healthcare providers to monitor and improve the outcomes of their care processes. Health professionals and managers can use these data to investigate where potential problems lie, and how they may be approached. On the basis of such analyses, care processes may be redesigned, and the indicators can then be used to monitor the influence of these improvement initiatives. Progress toward meeting internal quality indicators may be maintained confidentially, or used to benchmark against other organizations. In contrast, external indicators are used by various stakeholders (e.g., governments, accreditors and consumer organizations) to assess quality of care and cost-effectiveness. Comparison of results among organizations provides an indication of performance on a local, national or international level, and indicates how an organization benchmarks and performs against others. Often external quality indicators are publicly accessible.

The quality indicators in this chapter are presented using the now commonly accepted categorization developed by Donabedian (1988)² that relate to the type of care delivery the indicator addresses: structure, process or outcome. Structure indicators are related to attributes of the care setting, including organizational structure, material resources (e.g., environment, technology and tools), and human resources. Process indicators measure activities and tasks required to implement patient care at the care level (i.e., procedures which health professionals carry out). Outcome indicators describe the healthcare effects at the individual patient level.^{2,3}

Figure 1: Quality Indicators for Pressure Ulcers



Structure Indicators

1.1. The organization has a pressure ulcer prevention and treatment policy/protocol that reflects the current best practice outlined in this guideline.

Description	The organization has a policy/protocol governing the prevention and treatment of pressure ulcers that reflects current best practice.
Question	Does the organization have a policy/protocol governing the prevention and treatment of pressure ulcers that reflects current best practice?
Definition(s)	The organization’s pressure ulcer policy/protocol should reflect the current best practice outlined in this international guideline and relevant local requirements.
Source	Organization.
Measurement level	Organizational.
Rationale	A policy/protocol that reflects current best practice in the prevention and treatment of pressure ulcers determines interventions for preventing and treating pressure ulcers and promotes care delivery that is in accordance with best available evidence.
Evidence rationale	See the <i>Facilitators, Barriers and Implementation Strategy</i> section of the guideline.

1.2. Health professionals receive regular training in pressure ulcer prevention and treatment.

Description	Knowledge and skills of health professionals regarding pressure ulcer prevention and treatment must be current. This can be accomplished by providing regular access to mandatory evidence based training.
Question	Have all health professionals attended recent evidence based training in pressure ulcer prevention and treatment?
Definition(s)	Training refers to evidence-based education provided in any format (meetings, e-learning, etc.).
Source	Training calendar/health professional records.
Measurement level	Organizational and/or departmental.
Rationale	Receiving mandatory training on a regular basis promotes evidence-based knowledge and care delivery.
Evidence rationale	See the <i>Health Professional Education</i> section of the guideline.

1.3. Current information on pressure ulcer prevention and treatment is available for patient consumers and their caregivers in their own language.

Description	Current information about pressure ulcer prevention and treatment is made available to all patient consumers who are at risk of, or with, an existing pressure ulcer and their caregivers.
Question	Is current information about pressure ulcer prevention and treatment available for patient consumers and their caregivers in their own language?
Definition(s)	The information available has been updated within one year of an update of a national or international evidence-based guideline.
Source	Organization or department.
Measurement level	Organizational and/or departmental.
Rationale	Providing individuals at risk of, or with, an existing pressure ulcer with access to current, evidence-based education increases knowledge and skills; motivation to engage in self-care; and promotes the likelihood that appropriate care will be provided. Information may be verbal, printed or in digital formats; however, providing printed information allows patient consumers and their caregivers the opportunity to review the information at their own convenience. Where possible, written material should be provided in the preferred language of the patient consumer and caregivers.
Evidence rationale	See <i>Patient Consumers and Their Caregivers</i> section of the guideline.

1.4. The organization's pressure ulcer prevention and treatment protocol addresses the provision, allocation and use of pressure redistribution support surfaces.

Description	A pressure redistribution support surface protocol based on a national or international pressure ulcer guideline, must be available.
Question	Is a pressure redistribution support surface protocol based on a national or international pressure ulcer guideline, available?
Definition(s)	A support surface refers to a specialized device for pressure redistribution designed for management of tissue loads, microclimate, and/or other therapeutic functions.
Source	Document management system.
Measurement level	Department.
Rationale	Implementation of a pressure redistribution support surface protocol will guide decision making related to pressure redistribution support surfaces, and will aid in timely placement of patients on these surfaces.
Evidence rationale	See <i>Support Surfaces</i> section of the guideline.

Process Indicators

2.1. Every individual is assessed for pressure ulcer risk within eight hours after admission (i.e., first contact with a health professional or at first community visit), and the assessment is documented in the medical record.

Description	The percentage of individuals whose risk for developing a pressure ulcer is assessed and documented within a maximum of eight hours of admission (i.e., first contact with a health professional, or at the first visit for those in community care).
Numerator	Number of individuals whose risk for developing a pressure ulcer is assessed and documented within a maximum of eight hours of admission (i.e., first contact with a health professional, or at the first visit for those in community care).
Denominator	All admissions of at least eight hours' duration.
Definition(s)	The risk for developing a pressure ulcer is determined using a structured approach that incorporates assessment of the multiple epidemiological factors that increase the risk of pressure ulcer development.
Inclusion criteria	All admissions of at least eight hours' duration.
Source	Medical records.
Measurement level	Patient.
Rationale	Assessing the risk of pressure ulcer on admission facilitates the (timely) application of individualized preventive measures to reduce the risk of pressure ulcer.
Evidence rationale	See <i>Risk Factors and Assessment</i> section of the guideline.

2.2. Every individual received a comprehensive skin assessment within eight hours after admission (i.e., first contact with a health professional or at first community visit), and the assessment is documented in the medical record.

Description	The percentage of individuals whose skin is assessed and documented within a maximum of eight hours of admission (i.e., first contact with a health professional for inpatients, or at the first visit for those in community care).
Numerator	Number of individuals whose skin is assessed and documented within a maximum of eight hours of admission (i.e., first contact with a health professional for inpatients, or at the first visit for those in community care).
Denominator	All admissions of at least eight hours' duration
Definition(s)	Alterations to skin integrity provide an indication of pressure ulcer risk. A comprehensive head-to-toe skin assessment identifies any existing pressure ulcers and contributes to a risk assessment.
Inclusion criteria	All admissions of at least eight hours' duration.
Source	Medical records.

Measurement level	Patient.
Rationale	Assessing the skin on admission facilitates the (timely) application of wound care and contributes to the development of an individualized pressure ulcer prevention plan.
Evidence rationale	See <i>Skin and Tissue Assessment</i> section of the guideline.

2.3. An individualized pressure ulcer prevention plan is documented and implemented for every individual at risk of, or with, pressure ulcers.

Description	The percentage of individuals at risk of, or with, pressure ulcers for whom an individualized pressure ulcer prevention plan has been documented and implemented.
Numerator	The number of individuals at risk of, or with, pressure ulcers for whom an individualized pressure ulcer prevention plan has been documented and implemented.
Denominator	The number of individuals at risk of, or with, pressure ulcers.
Definition(s)	An individualized pressure ulcer prevention plan should detail at a minimum the individual's specific requirements with respect to ongoing risk and skin assessment, nutrition, repositioning, pressure redistribution support surfaces, and topical skin care. The plan should be consistent with the individual's goals and wishes.
Exclusion criteria	Individuals who have documented refusal of preventive care are excluded.
Source	Medical records.
Measurement level	Patient.
Rationale	Developing and implementing individualized preventive measures reduces the risk of developing a new pressure ulcer.
Evidence rationale	See the <i>Preventive Skin Care, Nutrition in Pressure Ulcer Prevention and Treatment; Emerging Therapies for the Prevention of Pressure Ulcers and Support Surfaces</i> section of the guideline.

2.4. An assessment of the individual is documented for individuals with a pressure ulcer.

Description	The percentage of individuals with a pressure ulcer for whom there is a documented comprehensive assessment.
Numerator	The number of individuals with a pressure ulcer for whom there is a documented comprehensive assessment.
Denominator	The number of individuals with a pressure ulcer.
Definition(s)	A comprehensive assessment must meet the criteria as described in the <i>Assessment of Pressure Ulcers and Monitoring of Healing</i> section of the guideline.

Inclusion criteria	Individuals with pressure ulcers.
Source	Medical records.
Measurement level	Patient.
Rationale	A comprehensive assessment provides information on the individual characteristics (e.g., nutrition, medical/social history, values and goals) that impact on the health status of the individual and his or her ability to heal. This underpins development of an individualized treatment plan that meets the goals of the individual.
Evidence rationale	See the <i>Assessment of Pressure Ulcers and Monitoring of Healing</i> section of the guideline for full outline of a comprehensive individual assessment.

2.5. Pressure ulcers are assessed and the findings are documented at least once a week.

Description	The percentage of individuals with a pressure ulcer who have a documented wound assessment in their record at least once a week.
Numerator	The number of individuals with a pressure ulcer who have a documented wound assessment in their record at least once a week.
Denominator	The number of individuals with a pressure ulcer.
Definition(s)	A wound evaluation can consists of: <ul style="list-style-type: none"> • Assessment of wound characteristics as outlined in the <i>Assessment of Pressure Ulcers and Monitoring of Healing and Assessment and Treatment of Infection and Biofilms</i> sections of the guideline. • A uniform and consistent method of measuring wound length and width or wound area; and wound depth. • The use of a valid and reliable pressure ulcer assessment tool.
Inclusion criteria	Individuals with pressure ulcers.
Source	Medical records.
Measurement level	Patient.
Rationale	Evaluating the healing process helps to determine whether the treatment method is yielding the desired clinical outcome. If not, reassess the individual, the pressure ulcer and the plan of care.
Evidence rationale	See <i>Assessment of Pressure Ulcers and Monitoring of Healing and Assessment and Treatment of Infection and Biofilms</i> sections of the guideline.

2.6. An individualized treatment plan and its goal, is available for each individual with a pressure ulcer.

Description	The percentage of individuals with a pressure ulcer for whom an individualized treatment plan and its goal has been documented.
Numerator	The number of individuals with a pressure ulcer for whom an individualized treatment plan has been documented.
Denominator	The number of individuals with a pressure ulcer.
Definition(s)	The treatment plan could include wound care, nutrition, pain management, pressure relief and redistribution, and education. Example of treatment goals include a time frame in which clean a granulating wound bed is achieved, expected time frame for healing and patient comfort. Treatment goals should be consistent with patient goals.
Inclusion criteria	Individuals with a pressure ulcer.
Source	Medical records.
Measurement level	Patient.
Rationale	Developing an individualized treatment plan allows for evidence-based treatment of the individual and the wound, which supports ongoing evaluation of interventions.
Evidence rationale	See the <i>Assessment of Pressure Ulcers and Monitoring of Healing</i> section of the guideline.

2.7. Every individual with a pressure ulcer has a documented pain assessment and where applicable, a pain management plan.

Description	The percentage of individuals with a pressure ulcer for whom pain assessment and management plan has been documented.
Numerator	The number of individuals with a pressure ulcer for whom pain assessment and management plan has been documented.
Denominator	The number of individuals with a pressure ulcer.
Definition(s)	A pain assessment is conducted using a valid and reliable scale appropriate to the individual that considers non-verbal expression of pain. A management plan incorporating evidence-based interventions is developed and documented for individuals who experience pain.
Inclusion criteria	Individuals with a pressure ulcer.
Source	Medical records.
Measurement level	Patient.
Rationale	Developing an individualized pain management plan promotes comfort and quality of life.
Evidence rationale	See the <i>Pain Assessment and Treatment</i> section of the guideline.

2.8. Every individual with an increased risk of pressure ulcers (and/or his or her caregiver) receives information about the prevention and treatment of pressure ulcers.

Description	The percentage of individuals at increased risk of pressure ulcers (and/or caregivers) who received information on preventing and treating pressure ulcer.
Numerator	The number of individuals at increased risk of a pressure ulcers (and/or caregivers) who received information on preventing and treating pressure ulcer.
Denominator	Number of individuals at increased risk of a pressure ulcer.
Inclusion criteria	Individuals at increased risk of pressure ulcer.
Source	Medical records and/or patient consultation.
Measurement level	Patient.
Rationale	Providing individuals at risk of, or with, an existing pressure ulcer with access to current, evidence-based education increases knowledge and skills; motivation to engage in self-care; and promotes the likelihood that appropriate care will be provided. Information may be verbal, printed or in digital formats.
Evidence rationale	See <i>Patient Consumers and Their Caregivers</i> section of the guideline.

Outcome Indicators

3.1. Percentage of individuals within the facility at a specific point in time with a pressure ulcer (point prevalence).

Description	The percentage of individuals with a pressure ulcer.
Numerator	The number of individuals at a specific point in time with a pressure ulcer. ⁴
Denominator	The number of individuals in the facility at the specific point in time. ⁴
Definition(s)	See the <i>NPUAP/EPUAP Pressure Ulcer Classification System</i> section of the guideline for definitions of Categories/Stages of pressure ulcers.
Exclusion criteria	Exclusions should be clearly reported (e.g. specific departments, such as outpatients or short-stay surgery, individuals on leave from the facility at the time of audit).
Source	Assessment of individuals using the NPUAP/EPUAP Pressure Ulcer Classification System.
Measurement level	Patient.
Rationale	The prevalence of pressure ulcers gives a general indication of the effectiveness of preventive and treatment strategies for pressure ulcers and an estimate of resources needed to address pressure ulcer treatment.

Evidence rationale	See the <i>Prevalence and Incidence of Pressure Ulcers, Classification of Pressure Ulcers</i> and <i>NPUAP/EPUAP Pressure Ulcer Classification System</i> sections of the guideline.
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3.2. Percentage of individuals who did not have a pressure ulcer on admission who acquire a pressure ulcer during their stay in the facility (facility-acquired rate).

Description	Percentage of individuals who did not have a pressure ulcer on admission who acquire a pressure ulcer during their stay in the facility. ⁴
Numerator	The number of individuals who did not have a pressure ulcer on admission who acquire a pressure ulcer during their stay in the facility. ⁴
Denominator	The number of individuals who did not have a pressure ulcer on admission. ⁴
Definition(s)	See the <i>NPUAP/EPUAP Pressure Ulcer Classification System</i> section of the guideline for definitions of Category/Stages of pressure ulcers.
Exclusion criteria	Exclusions should be clearly reported (e.g. specific departments).
Source	Assessment of individuals using the NPUAP/EPUAP Pressure Ulcer Classification System. Clinical audit provides a more reliable indication of facility-acquired pressure ulcer rates than a document review.
Measurement level	Patient.
Rationale	Facility-acquired rates provide a clearer indication of the effectiveness of the preventive measures used for pressure ulcers.
Evidence rationale	See the <i>Prevalence and Incidence of Pressure Ulcers, Classification of Pressure Ulcers</i> and <i>NPUAP/EPUAP Pressure Ulcer Classification System</i> sections of the guideline.

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FURTHER RESEARCH NEEDS

Introduction

The literature search underpinning the development of this guideline highlighted the paucity of research investigating the prevention and treatment of pressure ulcers using study designs that are at low risk of bias. Much of the research appraised in this guideline was at a moderate to high risk of bias. The Guideline Development Group recommends that future research prioritize the areas listed below.

Priorities for Future Research

This list outlines priorities for future research, but it is not a prioritized list.

Research Methods

- Standardized approaches to measure and report prevalence and incidence of pressure ulcers should be adopted in order to facilitate national and international benchmarking. See the *Prevalence and Incidence of Pressure Ulcers* section of the guideline for recommendations on approaches to measuring and reporting pressure ulcer rates.
- Standardized approaches to measure and report wound healing should be adopted.
- Consistent implementation of study designs and processes that are at low risk of bias are required, including:
 - Correctly powered trials.
 - Use of true randomization, wherever appropriate and possible.
 - Treatment groups/study populations being comparable at baseline.
 - Allocation to study groups being concealed.
 - Blinding of the participant, outcome assessor and data analyzer to study groups and/or outcome measurement, wherever possible.
 - Use of intention-to-treat analysis.

Etiology of Pressure Ulcers

- The concept of skin failure versus pressure ulcer requires further investigation.
- An increasing body of evidence suggests that the microclimate between the individual's skin and the support surface plays a role in the development of pressure ulcers. The importance of these issues and the characteristics of an optimal microclimate require further research.
- Although there is some evidence that high shear forces at the skin surface cause superficial ulcers and high pressure is responsible for wounds in deeper tissue layers, further investigation into the precise mechanisms by which damage occurs when skin is loaded with a high shear force is required.
- There is a substantial knowledge base regarding skeletal muscle and skin; however, there is a paucity of knowledge regarding the mechanical properties and damage thresholds of adipose tissue. This area requires further research.
- The role of the occlusion of lymph vessels, its relation to tissue edema and influence on pressure ulcer development is an area that warrants future research.
- Further guidance on concerns over the potentially unavoidable nature of some pressure ulcers is strongly recommended.

Risk Assessment and Early Detection

- As sensor technology becomes more sophisticated, cost effective and easy to use, and the ability to integrate this technology into clothing, wound dressings and linen, it is worthwhile investigating new opportunities for risk assessment, early detection and screening of individuals. As this technology is becoming more accessible, there is a necessity to explore which biophysical and biochemical markers

are the target markers for this type of screening. Fundamental research is needed using *invitro* and *invivo* model systems as well as pre-clinical studies with human volunteers.

- There is minimal good quality research investigating the effectiveness of formal risk assessment tools in identifying individuals at risk of pressure ulcers. Investigation into, and development of, risk assessment tools that incorporate newer research on factors that are associated with increased pressure ulcer risk, including factors that potential impact primary risk factors.

Preventive Care

- There is a need for further good quality research studies on the use of prophylactic dressings, including comparative studies between dressing types and exploration on the use of prophylactic dressings in special populations.

Nutrition

- There is currently a paucity of research on the role of energy and protein supplementation in prevention of pressure ulcers. Further research could investigate the use of supplementation in populations considered at high risk of pressure ulcers.
- The role of multivitamin and arginine supplementation in pressure ulcer prevention and healing requires further research.

Pain Management

- A solid evidence base on the influence of pain on the individual with the pressure ulcer has been documented. Further research on the most effective pharmacological and non-pharmacological strategies to manage pain associated with pressure ulcers is required; as well as strategies to ensure health professionals address pain associated with wounds.

Wound Healing Strategies

- The role of hyperbaric oxygen therapy in healing has had minimal exploration using robust research designs and appropriate outcome measures. Research on a potential role of this therapy is suggested.
- The effectiveness of phototherapy and laser therapy, and the selection of individuals for whom these therapies are likely to have a clinical effective outcome require further investigation using robust study designs and appropriate outcome measures.
- The role of traditional treatments and medicines (e.g., those used by Indigenous groups and Eastern and African cultures) is under represented in the literature on pressure ulcers. There is a strong need for robust research on traditional interventions.

Support Surfaces

- Research is needed on support surfaces that are most effective in supporting the healing of Category/Stage III, IV and unstageable pressure ulcers and suspected deep tissue injury.
- There is little evidence on pressure ulcer prevention in the seated population. At present it is not possible to recommend a most effective means of pressure redistribution in an armchair or wheelchair. More direct clinical research is needed on seat cushions, as well as positioning in the chair.
- Further robust studies should be undertaken to evaluate use of natural sheepskin as a support surface in pressure ulcer prevention.

Repositioning and Early Mobilization

- A fundamental way in which health professionals contribute to the prevention and treatment of pressure ulcers is by repositioning those individuals who are unable to reposition independently. Although repositioning is a practice with good validity, there are a limited number of clinical trials that have examined its effect. It is important to undertake robust research investigating the most effective repositioning regimens, in combination with the various pressure redistribution support surfaces

commonly used in clinical practice today.

- Although there is a high incidence and prevalence of heel ulcers, they have been the direct focus of very few studies. Research is needed to examine whether heel elevation strategies are more effective when matched to a specific individual's characteristics (e.g., duration and level of immobility and frequency and force of leg movement).

Managing Infection and Biofilms

- The impact of antibiotic resistant bacteria on the healing of chronic wounds, and strategies to reduce the unnecessary use of antibacterial treatments should be prioritized. This includes the role of topical agents (particularly polyhexamethylene biguanide [PHMB], silver and cadexomer iodine) in managing pressure ulcers.
- Minimal robust research has been conducted on best practice for preventing, diagnosing and eradicating biofilm in pressure ulcers and other chronic wounds and this is a priority for ongoing research.

Pressure Ulcer Prevention and Management in Special Populations

- There is little evidence on pressure ulcer prevention during surgery. More research is needed on frequency of pressure ulcer occurrence, risk factors (e.g., specific diagnoses, length of surgery), and prevention of pressure ulcers during surgery. This research should focus on pressure ulcer incidence as an outcome measure.
- Research is needed on which individual groups are at risk of pressure ulcers, and whether older adults differ from individuals with spinal cord injury in terms of pressure ulcer development.
- Research is needed on the most appropriate pressure relief regimens and pressure redistribution cushions for supported seating in individuals with spinal cord injury who have ischial and/or sacral pressure ulcers.
- Further research on the role of electrical stimulation of the muscles of individuals with spinal cord injury in order to create involuntary movement that relieves pressure is warranted based on the pilot trials reported in this guideline.
- There is minimal research conducted in pediatric populations, despite certain neonates and infants having a high risk for pressure ulcers. Research on the most appropriate support surfaces for pediatric populations should be a priority.

GLOSSARY OF TERMS

Abrasion: A loss of the epidermis through some mechanical process, such as friction or trauma.

Abscess: A localized collection of pus surrounded by inflamed tissue, usually due to an infective process.¹

Acute wound: A wound that progresses through the normal stages of healing without delay. In normal wound healing, signs of healing should be evident within two weeks.

Adjuvant: A substance (or therapy) that aids or heightens the action of another.

Albumin: Albumin makes up 60% of total protein in the blood. It decreases with stress, age, and impaired liver function. Albumin serves to maintain colloid osmotic pressure and as a transport protein for certain ions, hormones, medications, enzymes, fatty acids, amino acids, and bilirubin. It decreases with over-hydration, stress, infection, impaired renal function, and liver disease, among other causes. Normal albumin blood level is 3.5 to 5.4 gm/dL. Normal values may vary depending upon the laboratory performing analysis.

Anasarca: Diffuse, systemic edema arising from an accumulation of fluid in the interstitial space. Anasarca often occurs in congestive heart failure, liver failure, or renal disease.

Angiogenesis: The process of developing new blood vessels from pre-existing blood vessels within the wound space; an integral part of wound healing.²

Antibacterial: A term used to encompass antibiotics, antiseptics and disinfectants. A substance that inhibits the growth of, or eradicates, micro-organisms.^{3,4}

Antibiotic: A natural or synthetic substance administered systemically or topically that has the capacity to destroy or inhibit bacterial growth.^{1,3,4}

Antimicrobial: A substance that acts directly on a microorganism to destroy the bacteria and prevent the development of new bacterial colonies.⁵ An antimicrobial is a broad term that includes: antiseptics, disinfectants and antibiotics.⁶

Antiseptic: A substance that kills microorganisms.⁶

Aseptic technique: A wound care technique that may be considered when the individual is immunocompromised; the wound enters a sterile body cavity; during the peri-operative period; or when the wound healing environment is compromised.³ Aseptic technique is designed to prevent the introduction of new microorganisms into the wound, and to reduce cross infection risk and uses sterile products and devices.

Autolysis: see *Debridement*.

Avascular: Lacking or without blood supply; includes necrotic tissue, slough and eschar.¹

Bacterial bioburden: The quantity of microorganisms present (e.g., planktonic bacteria or biofilm). It can be categorized as:

Contamination: The presence of bacteria on the wound surface without bacterial multiplication⁵ and with no impairment to health or obvious clinical signs of infection.⁷

Colonization: The replication of microorganisms on the surface of the wound without invasion into wound tissue and without host immune response.⁸

Critical colonization (topical infection): Replication of microorganisms in low numbers of planktonic bacteria ($\leq 10^5$ CFU/gm) and potential presence of biofilm. Bacteria and/or their products have invaded the wound surface and impaired the healing process. Clinical signs of infection may be present.⁷

Local infection: The presence of bacteria or other microorganisms in sufficient quantity to damage tissue and/or impair healing. A wound is classified as infected when the tissue contains $\leq 10^5$ CFU/gm microorganisms per gram of tissue. Typical signs and symptoms of infection include purulent exudates, odor, erythema, warmth, tenderness, edema, pain, fever, and elevated white blood count. In some instances, clinical signs of infection may not be present, especially in the immunocompromised individual or individual with poor perfusion.¹

Cellulitis (regional infection, spreading infection): Bacteria and/or their products have invaded surrounding tissues causing diffuse, acute inflammation and infection of skin or subcutaneous tissues.^{1,7}

Sepsis (bacteremia): Bacteria and/or their products have entered the bloodstream. Impairment to healing occurs and the individual presents with systemic clinical signs.⁷

Bacteremia: see *Bacterial bioburden*.

Barrier film/cream/ointment: Substance used as a protective layer (barrier) to prevent or correct skin irritation.

Biofilm:	Page:	317
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An aggregate of microorganisms known to cause chronic inflammation such as periodontal disease, surgical device infections and urinary catheter infections.⁹ Biofilms have enhanced resistance to destruction by endogenous antibodies and phagocytic cells, as well as by exogenous antibiotics and antiseptics. Biofilms play an important role in maintaining a chronic inflammation state ultimately leading to the failure to heal of skin wounds.¹⁰ Also see *Bacterial bioburden*.

Biophysical agent: An agent used to deliver a specific treatment substance to a wound, e.g., oxygen, negative pressure wound therapy, pulsatile lavage with suction, electrical stimulation or whirlpool, among many others.

Blanchable erythema: see *Erythema*.

Body mass index (BMI): Defined as an individual's weight in kilograms divided by the square of his height in meters. The term bariatric, derived from the Greek word *baros* meaning heavy and *iatic* relating to the medical treatment of this condition, is used to refer to individuals with a BMI > 30 kg/m².

Bolster pad: A pad used as a support.

Bony prominence: A bony elevation or projection on an anatomical structure.¹

Bottoming out: Occurs when a reactive or an active support surface provides insufficient support to adequately redistribute pressure due to excessive immersion.⁴ The individual presents as sitting or lying on the underlying structure of the bed or chair.

Bridging: The presence of strands of tissue across the ulcer bed.

Callus: Painless thickening of the skin at locations of pressure or friction, frequently seen on the foot.

Cellulitis: see *Bacterial bioburden*.

Chronic wound: A wound that does not proceed through the normal stages of healing in an orderly fashion but becomes stuck in one phase of healing.

Clean technique: A wound care technique that is designed to minimize the number of organisms introduced to a wound and to reduce the risk of cross infection.³ Wound cleaning is performed using clean, potable water with either clean or sterile products (depending on local protocols). As most chronic wounds have some level of bacterial colonization, clean technique is appropriate for most pressure ulcers.

Coefficient of friction: A measurement of the amount of friction existing between two surfaces.¹¹

Collagen: The most abundant protein of the dermis, accounting for 70 to 80% of its dry weight; the main supportive protein of the skin and connective tissue.

Contraction: Pulling together wound edges in the healing process.

Contour seating: A seating product that increases contact area with the body by providing a contour that resembles the typical human form.

Crepitus: A cracking, crunchy, or popping sensation upon palpation of soft tissue related to underlying gas in the tissue released by anaerobes; indicative of the presence of air bubbles in the tissue.

Culture: A laboratory test involving the growth of bacteria or other cells in a special growth medium. Cultures are grown to identify an organism as well as which antibiotics are effective in combating the organism(s).

Cytotoxic: A substance that damages or kills living cells.

Dead space: An area of tissue loss in a cavity or tract.

Debridement: The removal of devitalized (non-viable) tissue from or adjacent to a wound.⁴ The process effaces the wound bed of exudates, detaches bacterial colonies, and allows a stimulatory environment to be established.

Autolytic debridement (autolysis): A highly selective form of slow debridement that occurs naturally in wounds¹² and is promoted the use of moisture-retentive dressings.¹³

Biological debridement (larval therapy): The use of sterile fly larvae to remove devitalized tissue. Larvae are believed to secrete a proteinase enzyme that degrades necrotic tissue, digests bacteria, and stimulates granulation tissue.¹⁴

Conservative sharp debridement: The removal of devitalized tissue using a sharp instrument (e.g., scalpel, scissors or curette).¹

Enzymatic debridement: The removal of devitalized tissue by applying exogenous proteolytic or fibrinolytic enzymes.¹³

Maintenance debridement: Repeated debridement until devitalized (non-viable) tissue is removed from the wound bed.

Mechanical debridement: Non-selective removal of devitalized tissue by physical forces.¹³

Surgical/sharp debridement: rapid wound debridement in which devitalized tissue is removed from the wound using scalpel and/or scissors under general or local topical anesthetic.

Deep tissue injury (DTI): See *Suspected deep tissue injury*.

Denuded: Loss of epidermis.

Desiccation: The drying of the wound bed.

Devitalized tissue: Tissue that is devoid of vitality or life (non-viable). It is normally moist, yellow, green, tan, or gray and may become thick and leathery with dry black or brown eschar.

Electrical stimulation: The use of an electrical current to transfer energy controlled by an electrical source. In the prevention and treatment of pressure ulcers, electrical stimulation is used as a wound healing therapy and is emerging as a therapy to stimulate muscles in individuals who are unable to reposition.

Wound electrical stimulation: electrodes are usually placed over a wet conductive medium (saline

soaked gauze, gel, or conductive gel) in the wound bed and on the skin a distance away from the wound or by indirectly by placing electrodes on opposite sides (bracketing) of the wound.

Muscle electrical stimulation: surface electrodes are placed over the (usually gluteal or hamstring) muscle, generally using specially designed clothing with inbuilt electrodes. The electrical current induces intermittent tetanic muscle contractions temporarily reshape the muscle and redistributing pressure.¹⁵

Electromagnetic spectrum (EMS): is an energy source that affects living systems. The EMS comprises infrared (thermal radiation), ultraviolet light (invisible light), laser (coherent and monochromatic light) and electrical/electromagnetic stimulation.

Emollient: A substance applied externally to soothe and hydrate the skin by contributing to the stratum corneum hydration.¹⁶

Enhanced food: see *Fortified food*.

Enteral nutrition: Nutritional support given via a nasogastric, nasoenteral, or percutaneous tube. Enteral nutrition is used when the gastrointestinal tract is functioning.¹⁷

Epibole: A condition that exists when the edges of the top layers of epidermis have rolled down and healing stops.¹

Epidermis: The outermost layer of skin.

Epithelialization: The process of becoming covered with or converted to epithelium. The new epithelial cells advance across the wound bed until they meet epithelial cells coming from the opposite direction.

Eschar: Black or brown necrotic, devitalized tissue. The tissue can be loose or firmly adherent and hard, soft, or somewhat soggy.¹

Erythema: Redness of the skin due to dilation of superficial capillaries.¹

Blanchable erythema: An area of reddened skin that temporarily turns white or pale when pressure is applied to the skin. Over a pressure site, this is due to a normal hyperemic response.¹⁸

Nonblanchable erythema: Redness that persists following the application of fingertip pressure, usually over a bony prominence. Darkly pigmented skin may not have visible blanching. This is a sign of a Category/Stage I pressure ulcer.

Excoriation: The loss or stripping of superficial skin, usually in the perineal/buttocks areas, from the presence of moisture or caustic substances.

Extrinsic factors: Originating outside of the body.

Exudate: Fluid extruded from a tissue or capillaries that can include fluid, cells, or cellular debris that has escaped from blood vessels and been deposited in tissue surfaces. It may contain serum, cellular debris, bacteria, and leukocytes.^{1,19}

Fascia: A sheet or band of fibrous tissue that lies deep below the skin or encloses muscles and various organs of the body.

Fibroblast: The cells from which connective tissue develops. Fibroblasts proliferate in the deeper parts of a wound and begin synthesizing small amounts of collagen, which serves as a scaffold for migration of cells and further fibroblast proliferation.¹

Fistula: An abnormal passage from an internal organ to the body surface or between two internal organs.¹

Flap: A flap is a surgical relocation of tissue from one part of the body to another part in order to reconstruct a primary defect. Flaps may be skin flaps, cutaneous flaps or composite flaps. The flap is often cut and rotated to a neighboring site.

Float: A method used to relieve a body part, such as the heel, of pressure.

Fortified foods: Normal food enriched with specific nutrients, in particular with energy and /or protein, minerals, vitamins, or trace elements.

Frequent small shifts: Frequent shifts in the position of the individual, which may be only 10° to 15° at a time; a procedure used to reposition an individual who may be hemodynamically unstable.

Friable: Fragile, easily injured, characteristic of newly healed tissue.

Friction (frictional force): The resistance to motion in a parallel direction relative to the common boundary of two surfaces, e.g., when skin is dragged across a coarse surface, such as bed linens ¹¹.

Friction blister: An area of skin that becomes red, inflamed or broken as a result of rubbing or sliding along a surface. A friction blister is not considered to be a pressure ulcer.

Full thickness skin loss: Ulceration that extends through the dermis to involve the subcutaneous tissue (Category/Stage III and IV pressure ulcers) and, if a Category/Stage IV pressure ulcer, extends into the muscle and possibly down to the bone.

Functionality: This refers to the intended, proper use for which the product was designed.

Functional life span: The designated time period for which a support surface was designed and intended to fulfill its original function.

Granulation tissue: The pink/red, moist, shiny tissue that glistens and is composed of new blood vessels, connective tissue, fibroblasts, and inflammatory cells that fills an open wound when it begins to heal. It typically appears deep pink or red with an irregular, granular surface.¹

Growth factors: Naturally occurring proteins or hormones that stimulate cell growth.

Hematoma: A collection of blood as a result of bleeding.

Hemorrhage: Bleeding (may be internal or external).

Host response: The reaction of the individual to the invasion of the microorganism.

Hydrotherapy: The use of a whirlpool or other submersion in water for cleansing.¹

Hyperbaric oxygen: Therapy in which the individual breathes 100% oxygen at pressure greater than normal atmospheric (sea-level) pressure or more than 1 atmosphere absolute (ATA).

Incidence: The proportion of pressure ulcer free individuals that develop a pressure ulcer over a specific period of time.²⁰ Because measuring true incidence is resource intensive, often a facility-acquired prevalence rate is reported (also referred to as nosocomial, hospital-acquired or healthcare-acquired pressure ulcer rate). Also, see *Prevalence*.

Incontinence-associated dermatitis (IAD): A reactive skin response of inflammation and erythema that occurs from chronic exposure to urine and feces and may or may not include erosion or denudation.²¹

Induration: Tissue that is hardened to touch.

Infection: The presence of bacteria or other microorganisms in sufficient quantity to damage tissue or impair healing. Clinical signs of infection may not be present in the immunocompromised individual or the individual with a chronic wound. See *Bacterial bioburden*.

Infrared therapy: Treatment using thermal radiation, a phototherapeutic agent that is part of the electromagnetic spectrum.

Interface pressure: The force per unit area that acts perpendicularly between the body and a support surface. This parameter is affected by the stiffness of the support surface, the composition of body tissue, and the geometry of the body being supported.¹

Integrated bed system: A bed frame and support surface that are combined into a single unit whereby the surface is unable to function separately.¹¹

Intertrigo: An erythematous skin eruption that occurs on opposing surfaces of skin (e.g., the creases of the neck, folds of the groin and armpit, or beneath pendulous breasts) from moisture, warmth, friction, and/or infectious agents. It occurs more commonly in bariatric individuals.

Intrinsic factors: Originating within the body.

Laser: Coherent and monochromatic light, a phototherapeutic agent that is part of the electromagnetic spectrum.

Lateral rotation therapy: A continuous, slow rotation cycle that redistributes pressure in high-risk, critically ill individuals. The degree of rotation can be adjusted to the individual's tolerance, although it is commonly set at 40° in cases of respiratory distress. Specific criteria for the use of this therapy have been established.²²⁻²⁴

Lift (pressure relief lift): The lifting of oneself or the body from a seated surface to temporarily relieve pressure.

Likert scale: An interval-based multiple-choice style question frequently used in questionnaires.

Macerate: To soften by wetting or soaking.

Maggot therapy: see *Debridement*.

Malnutrition: Malnutrition defined as any nutritional imbalance²⁵ and is synonymous with the term undernutrition.

Malodor: An offensive or disagreeable odor.

Matrix metalloprotease (MMP): A cell protein that plays an essential role in wound healing, including contraction of the wound matrix through the use of myofibroblasts, implementation of angiogenesis, cell migration, remodeling of scar extracellular matrix (ECM), and removal of damaged ECM.²

Medical grade honey: Honey that is filtered, gamma irradiated and produced under exacting standards of hygiene.

Medical grade sheepskin: A sheepskin that complies with the internationally recognized Australian Standard AS4480.1-1998.⁴

Microclimate: The local tissue temperature and moisture (relative humidity) level at the body/support surface interface.¹¹

Micronutrient: A micronutrient is a chemical element or substance required in very small amounts for normal growth and development.

Mobility: The ability to move oneself from one position to another.

Necrosis: The death of tissue.

Necrotic tissue: Tissue that has died, also called devitalized or non-viable tissue.

Negative-pressure wound therapy (NPWT): A wound treatment modality that promotes healing through the removal of third space edema, thus enhancing nutrient and oxygen delivery; removal of wound exudates, which is the medium for bacterial colonization; promotion of granulation tissue; promotion of angiogenesis; and removal of wound inhibitory factors.

Nutritional supplement: A commercial or other prepared food or beverage that supplements energy, protein, carbohydrate, and/or fiber.

Offload: To remove pressure from any area.

Oral nutritional supplement: A commercial or other prepared food or beverage that supplements nutrient and caloric intake.

Osteomyelitis: The inflammation of bone and bone marrow, usually caused by pathogens that enter the bone during an injury or surgery.¹

Overlay: An additional support surface designed to be placed directly on top of an existing surface.

Palliative care: Care focused on holistically supporting the individual for comfort rather than cure, or healing of the wound, while enhancing the quality of living and dying.²⁶

Pannus: A hanging flap of tissue; abdominal tissue in a bariatric individual.

Parenteral nutrition: The provision of macronutrients, vitamins, minerals, electrolytes, and fluids via a central or peripheral vein that is indicated when the gastrointestinal tract cannot be used for nutritional support. Total parenteral nutrition (TPN) provides all essential nutrients and is delivered through of central vein.

Partial thickness skin loss: Skin damage that involves the epidermis and can penetrate into but not through the dermis. Includes Category/Stage I and II pressure ulcers.

Periwound: The area immediately adjacent to the wound edge and extending out as far as the tissue color and consistency changes extend.

pH: A measure on a scale from 0 to 14 of the acidity or alkalinity of a solution, with 7 being neutral, greater than 7 is more alkaline and less than 7 is more acidic.

Phagocytosis: The process of the ingestion and digestion of bacteria, cells, necrotic tissue, or debris by white blood cells in an injured area.

Phototherapy: An agent that employs energy waves from the infrared, visible, and ultraviolet region of the electromagnetic spectrum. Combinations of these technologies are often used.²⁷

Planktonic bacteria: Free-floating bacteria. Also see *Bacterial bioburden*.

Pocketing: This occurs when granulation tissue does not grow in a uniform manner across the entire wound or when healing does not progress from the bottom up to the top of the wound. Pockets can harbor bacteria.

Potable water: Water that is fit for consumption by humans and animals.

Pounds per square inch (PSI): A unit of pressure exerted by a stream of fluid against one square inch of skin or wound surface.¹

Prealbumin: A body protein whose function is to transport thyroxine and complexes with retinol-binding protein for Vitamin A transport. The normal level is 15 to 36 mg/dL, but it can vary with the laboratory determining the level.

Pressure: Normal force per unit surface area.

Pressure injury: see *Pressure ulcer*.

Pressure ulcer (pressure injury): a localized injury to the skin and/or underlying tissue, usually over a bony prominence, as a result of pressure or pressure in combination with shear. A number of contributing or confounding factors are also associated with pressure ulcers; the significance of these factors has yet to be elucidated. (See the *Etiology of Pressure Ulcers* section of the guideline). Previously referred to as decubitus ulcer, bedsore and pressure sore.

Prevalence: The proportion/percentage of individuals in a defined population who have a pressure ulcer at a specified point in time.

Point prevalence: Measures the proportion of a defined population (e.g., individuals in a hospital) who have a pressure ulcer at a specific moment in time (e.g., on a specific day).²⁸

Period prevalence: Measures the proportion of a defined population (e.g., individuals in a hospital) who have a pressure ulcer over a period of time (e.g., over a week).

Proinflammatory cytokines: A body substance liberated in the presence of inflammation and infection, e.g., interleukin-1 and tumor necrosis factor, which in turn increases the levels of matrix metalloproteases (MMPs), decreases the level of inhibitors in tissue against the MMPs, and decreases the production of growth factors and fibroblast activity.²⁹ They play a critical role in regulating the integrated hepatic acute-phase protein response.

Prophylactic dressing: A dressing that is placed onto the skin before any skin damage is evident with a goal of preventing skin breakdown due to pressure, shear and alternations in the skin's microclimate. Features such as an elastic adhesive type (e.g. silicone), the number of dressing layers and their construction, and the size of the selected dressing all contribute to its ability to protect the skin.³⁰

Protease: A proteolytic enzyme.

Protein: A complex organic compound made up of chains of amino acid molecules. Proteins are responsible for the repair of injured tissue, fluid balance, antibody production, cellular function, and hormonal and enzymatic function. Proteins are a source of building material for muscle and for healing wounds.

Protectant (skin): A substance applied externally to the skin to protect it from harmful substances.

Protein-calorie malnutrition: This occurs when both protein and energy intake are insufficient to meet an individual's metabolic demands. The wasting and excessive loss of lean body mass resulting from too little energy being supplied to the body tissue can be reversed solely by the administration of nutrients.³¹

Proteolytic enzyme: An endogenous substance such as collagenase, alastase, myeloperoxidase, acid hydrolase, and lysozymes that selectively liquefies and separates necrotic tissue and eschar from healthy tissue.¹²

Pulsatile lavage: The delivery of irrigation fluid in rapid, discrete pulses via a disposable, battery-powered unit that delivers variable irrigation pressures with or without concurrent suction. The pulsation of the irrigation fluid may increase the amount of debris removed. Concurrent suction immediately removes irrigation fluid that has been contaminated by contact with the wound.¹

Purulent: Containing pus.

Quality of life: An individualized, qualitative measure of the impact of disease, treatment, and/or disability on the individual's ability to lead a fulfilling life.³²

Reactive hyperemia: A reddening of the skin caused by blood rushing back into ischemic tissue.

Reepithelialization: The replacement of the epithelial layers of the tissue.

Reposition: A change in position in the lying or seated individual, with the purpose of relieving or redistributing pressure and enhancing comfort, undertaken at regular intervals.

Risk assessment: An assessment to determine which, if any, risk factors are present that might contribute to the development of a pressure ulcer.¹

Semi-Fowler position: A position in which the individual is supine and the head of the bed is elevated 30°.

Sepsis: see *Bacterial bioburden*.

Seroma: A collection of serum/plasma within a wound.

Sinus tract: A course or path of tissue destruction, sometimes called a tunnel, occurring in any direction from the surface or edge of a wound. It results in dead space with a potential for abscess formation. A sinus can be distinguished from undermining in that it involves only a small portion of the wound edge whereas undermining involves a significant portion of the wound edge.¹

Slough: Soft, moist, devitalized (non-viable) tissue. It may be white, yellow, tan, or green, and it may be loose or firmly adherent.¹

Silver sulfadiazine: A silver-based, rapidly absorbed, and fairly quickly excreted antibacterial agent.

Standard (usual) care: A term most often used in research studies to describe usual care delivered within a facility that is often the comparator intervention when pressure ulcer prevention interventions are being investigated. Standard care varies according to the setting and historical context. Within the context of this guideline, a description of the standard care is provided when available.

Standard hospital mattress: A term used to describe the standard mattress provided within a facility and generally used as the comparative intervention in research trials investigating the effectiveness of pressure redistribution support surfaces. As such, the qualities of a standard hospital mattress vary according to historical and clinical context and are rarely reported in detail in clinical trials. In most cases it is assumed that a standard hospital mattress is a non-powered foam or spring-based mattress.

Statistical concepts:

Confidence interval (CI): a measure of the reliability of an estimated statistic, i.e. confidence that the true value will fall within the interval range. In most clinical studies, a 95% CI is used (i.e. 95% confidence that the true value is within the stated range).

Cohen's kappa (κ): a statistical measure of interrater or interrater agreement.

Odds ratio (OR): a measure of association between an exposure and an outcome that represents the odds that an outcome (e.g., a pressure ulcer) will occur given a particular exposure (e.g., a pressure ulcer prevention program) compared to the odds of the outcome occurring in the absence of the exposure.³³

Multivariable model: a statistical model that has multiple independent variables that investigates the independent relationships between variables.³⁴

Multivariate model: a statistical model that has two or more dependent or outcome variables, often derived from longitudinal studies in which outcomes are measured on the same individual multiple times.³⁴

Negative likelihood ratio: A statistical measure that indicates the likelihood an individual does not have a specific condition after receiving a negative test result, factoring in the probability of a false negative result. Unlike the predictive value, the likelihood ratio is not dependent on the prevalence of the condition within the population. A smaller negative likelihood ratio indicates a lower likelihood of disease, given a negative test result.³⁵

Negative predictive value: the proportion of individuals with negative test results who do not have a specific condition, with consideration to the prevalence of the condition within the population.³⁵

Kaplan-Meier survival curves: A curve plot that is generated in a survival analysis. A survival analysis is used to investigate the amount of time it takes until participants a trial develop a specific clinical outcome end point (e.g., development of a pressure ulcer).³⁶

Pearson's r (r): a measure of the strength and direction of the linear relationship between two variables (correlation).

Positive likelihood ratio: A statistical measure that indicates the likelihood an individual has have a specific condition after receiving a positive test result, factoring in the probability of a false positive result. Unlike the predictive value, the likelihood ratio is not dependent on the prevalence of the condition within the population. A larger positive likelihood ratio indicates a greater likelihood of disease, given a positive test result.³⁵

Positive predictive value: the proportion of individuals with positive test results who truly have a specific condition, with consideration to the prevalence of the condition within the population.³⁵

P value (p): see *Statistically significant*.

Receiver Operator Curve, Area Under (AUROC): a measure of an overall accuracy of a specific test, with a value approaching 1.0 indicating a high sensitivity and specificity.³⁴

Relative risk (risk ratio): The risk of a particular outcome (e.g., a pressure ulcer) occurring in the presence of a particular exposure (e.g., a pressure ulcer prevention program) compared to the risk without the particular exposure. A RR of 1.0 indicates no difference in outcome risk between exposure and non-exposure.

Sensitivity: The proportion of individuals in a trial with disease or condition who test positive when undergoing a particular test. Thus, sensitivity indicates how well a particular test accurately detects a specific condition that is actually present.³⁵

Statistically significant: A term that refers to the observed difference between groups being unlikely to have occurred due to chance. In most clinical trials a p value of ≤ 0.05 is arbitrarily set as indicating statistical significance, and indicates that there is less than a 5% probability that chance led to the trial outcomes.

Specificity: The proportion of individuals in a trial without disease or condition who test negative when undergoing a particular test. Thus, specificity indicates how well a particular test accurately rules out a specific condition when the condition is not present.³⁵

Strain: A measurement of relative deformation.

Stress: Force transferred per unit area.

Support surface: A specialized device for pressure redistribution designed for management of tissue loads, microclimate, and/or other therapeutic functions. Support surfaces include but are not limited to mattresses, integrated bed systems, mattress replacements or overlays, or seat cushions and seat cushion overlays.

Support surfaces: physical concepts:

Active support surface: A powered support surface that produces alternating pressure through mechanical means and has the ability to change its load distribution properties with or without an applied load.⁴

Coefficient of friction: A measurement of the amount of friction existing between two surfaces.¹¹

Envelopment: The ability of a support surface to conform to irregularities in the body.^{11, 37, 38}

Fatigue: The reduced capacity of a surface or its components to perform as specified. This change may be the result of intended or unintended use and/or prolonged exposure to chemical, thermal, or physical forces.¹¹

Force: A push/pull vector with magnitude (quantity) and direction (pressure and shear) that is capable of maintaining or altering the position of a body.^{11, 39}

Friction (frictional force): The resistance to motion in a parallel direction relative to the common boundary of two surfaces.¹¹

Immersion: The depth of penetration (sinking) into a support surface.^{11, 37, 38}

Life expectancy: The defined period of time during which a product is expected to effectively fulfill its designated purpose.¹¹

Mechanical load: The force distribution acting on a surface.¹¹

Pressure: The force per unit area exerted perpendicular to the plane of interest.¹¹

Pressure redistribution: The ability of a support surface on which an individual is placed to distribute load over the contact areas of the human body, thereby reducing the load on areas in contact with the support surface. This term replaces prior terminology of pressure reduction and pressure relief surfaces.¹¹

Pressure relief: see *Pressure redistribution*.

Reactive support surface: A powered or non-powered support surface with the ability to change its load distribution properties only in response to applied load.^{11, 40, 41}

Shear (shear stress): The force per unit area exerted parallel to the plane of interest.^{11, 39}

Shear strain: The distortion or deformation of tissue as a result of shear stress.^{11, 31, 39}

Support surfaces: components: The components of any support surface described below may be used alone or in combination.

Air: A low-density fluid with minimal resistance to flow.¹¹

Cell/bladder: A means of encapsulating a support medium.¹¹

Closed-cell foam: A non-permeable structure in which there is a barrier between cells, preventing gases or liquids from passing through the foam.¹¹

Elastic foam: A type of porous polymer material that conforms in proportion to the applied weight. Air enters and exits the foam cells more rapidly due to greater density (non-memory).^{11, 38}

Elastomer: Any material that can be repeatedly stretched to at least twice its original length. Upon release, the stretch will return to approximately its original length.¹¹

Gel: A semi-solid system of a network of solid aggregates, colloidal dispersions, or polymers, which may exhibit elastic properties. Gels can range from hard to soft.¹¹

Open cell foam: A permeable structure in which there is no barrier between cells, and gases or liquids can pass through the foam.¹¹

Pad: A cushion-like mass of soft material used for comfort, protection, or positioning.¹¹

Solid: A substance that does not flow perceptibly under stress. Under ordinary conditions, it retains its size and shape.¹¹

Viscoelastic foam: A type of porous polymer material that conforms in proportion to the applied weight. The air enters the foam cells slowly, which allows the material to respond more slowly than a standard elastic (memory) foam.^{11, 42}

Viscous fluid: A fluid with a relatively high resistance to flow of the fluid.¹¹

Water: A moderate density fluid with moderate resistance to flow.¹¹

Support surface features: A feature is a functional component of a support surface that can be used alone or in combination with other features.

Air fluidized: A feature that provides pressure redistribution via a fluid-like medium created by forcing air through beads, as characterized by immersion and envelopment.¹¹

Alternating pressure: A feature that provides pressure redistribution via cyclic changes in loading and unloading, as characterized by frequency, duration, amplitude, and rate of change parameters.¹¹

Lateral rotation: A feature that provides rotation about a longitudinal axis, as characterized by degree of turn, duration, and frequency.¹¹

Low air loss: A feature that provides a flow of air to assist in managing the heat and humidity (microclimate) of the skin.^{11, 31}

Multi-zoned surface: A surface in which different segments can have different pressure redistribution capabilities.¹¹

Zone: A segment with a single pressure redistribution capability.¹¹

Support surface categories:

Active support surface: A powered support surface with the capability to change its load distribution properties, with or without applied load.

Integrated bed system: A bed frame and support surface that are combined into a single unit, whereby the surface is unable to function separately.

Mattress: A support surface designed to be placed directly on the existing bed frame.

Non-powered: Any support surface that does not use external sources of energy, either electric or battery, for operation.

Overlay: An additional support surface designed to be placed directly on top of an existing surface.^{11, 40, 41}

Powered: Any support surface requiring or using external sources of energy to operate, either electric or battery.¹¹

Reactive support surface: A powered or non-powered support surface with the capability to change its load distribution properties only in response to applied load.¹¹

Tensile strength: The maximum force or pressure that can be applied to a wound without causing it to break apart.

Tissue-interface layer: The point at which a dressing is in direct contact with the skin (wound bed).

Tissue ischemia: The reduction of oxygen levels to below normal.

Topical antibiotic: See *Antibiotic*.

Transfer aid: Any agent that aids in transferring an individual (e.g. a sheet, mechanical lift).

Surfactant: A surface active agent that reduces the surface tension of fluids to allow greater penetration.¹

Suspected deep tissue injury: Purple or maroon localized area of discoloured, intact skin or blood-filled blister due to damage of underlying soft tissue from pressure and/or shear. The area may be preceded by tissue that is painful, firm, mushy, boggy, or warmer or cooler than adjacent tissue. Deep tissue injury may be difficult to detect in individuals with dark skin tones. Evolution may include a thin blister over a dark wound bed. The wound may further evolve and become covered by thin eschar. Evolution may be rapid exposing additional layers of tissue even with treatment.

Tunneling: See *Sinus tract*.

Turn: The act of changing position.

Ultrasound: A mechanical vibration (acoustic energy) transmitted in a wave formation at frequencies beyond the upper limit of human hearing. Its vibratory property affects the cells of biologic tissues, and can be used to assess and treat soft tissues.

Ultraviolet light therapy: A form of therapy that uses an invisible light that is part of the electromagnetic spectrum and can be used as a phototherapeutic agent.

Undermining: An area of tissue destruction extending under intact skin along the periphery of a wound commonly seen in shear injuries. It can be distinguished from a sinus tract in that it involves a significant portion of wound edge.¹

Undernutrition: see *Malnutrition*.

Unintentional weight loss: Gradual, unintended weight loss over time.

Unstageable pressure ulcer: Full thickness tissue loss in which actual depth of the ulcer is completely obscured by slough (yellow, tan, gray, green, or brown) and/or eschar (tan, brown, or black) in the wound bed. Until enough slough and/or eschar is removed to expose the base of the wound, the true depth cannot be determined, but it will be either a Category III or IV pressure ulcer. Stable (dry, adherent, intact, without erythema or fluctuance) eschar on the heels serves as a natural (biological) cover and should not be removed.

Whirlpool: A hydrotherapy approach using water with or without additives or saline to stimulate wound healing and to cleanse and debride chronic wounds.

Wound dressing: A material applied to a wound for a variety of reasons, including promotion of healing, protection, absorption and drainage of exudate, control of odor and minimization of pain.

Wound dressing types:

Alginate: A highly absorbent, biodegradable dressing derived from non-woven absorptive material manufactured from seaweed. They are available in sheet and rope form.¹

Cadexomer iodine dressing: A dressing consisting of spherical hydrophilic beads of cadexomer-starch that contain iodine. It is highly absorbent and releases iodine slowly in the wound area. Cadexomer iodine is also available as a topical cream.

Collagen matrix: A dressing manufactured from bovine, porcine, or avian collagen that has been shown to reduce the levels of proteases in chronic wounds. It is available in sheets and pads, and as particles and gels.

Composite: A dressing that is a combination of two or more types of dressing.

Cover dressing: Dressing used as the top layer to cover other absorbent dressings.

Fiber methylcellulose: Highly absorbent dressing, chemically similar to a hydrocolloid.

Filler dressing: Dressing material used to fill dead space in a wound bed.

Foam: A sponge-like polymer dressing that may be impregnated or coated with other materials and has some absorptive properties. Simple foams wick drainage from the wound bed and move it to the surface of the dressing. Complex polyurethane foam dressings absorb the fluid, move it throughout the dressing, and retain it. Foam dressings also allow fluid to evaporate.

Gauze: A woven dressing, usually made from cotton or synthetic material, that is absorptive and permeable to water, water vapor, and oxygen. Gauze can be impregnated with petrolatum, antiseptics, or other agents.¹

Honey impregnated: A dressing that produces hydrogen peroxide, contains antioxidants, and releases anti-inflammatory products. Odor is reduced because the honey produces an alternative product for bacterial metabolism that yields lactic acid rather than ammonia, amines, and sulfur, which are odorous. Honey must be of medical-grade.

Hydrocolloid: A flexible dressing containing gel-forming agents, such as sodium carboxymethylcellulose (NaCMC), pectin and gelatin. In many products, these are combined with elastomers and adhesives and applied to a carrier (usually polyurethane foam or film) to form an absorbent, self-adhesive, waterproof wafer.¹

Hydrogel: A water-based, non-adherent gel that contains hydrated hydrophilic polymers, which produce a moist environment that improves wound healing. The dressing is able to absorb excess exudates from exuding wounds but donate moisture to dry, necrotic tissue or slough. The dressing facilitates autolytic debridement.¹

Polymeric membrane: A foam dressing combined with glycerin to soften devitalized tissue in the ulcer and starch to wick away exudates. The dressing also contains a surfactant that loosens necrotic tissue from the wound bed.⁴³

Silicone: A dressing composed of silicone, which is chemically inert and, therefore does not chemically interact with the wound. It is insoluble in wound exudates. This dressing provides a wound contact layer that can be removed atraumatically and without pain for the individual.

Silver impregnated: A dressing product impregnated with ionic silver for immediate or sustained release of silver into the wound bed. Silver provides a barrier to bacterial penetration.⁴⁴

Transparent film: A transparent dressing that is nonabsorptive and polymer-based, making it permeable to oxygen and water vapor but not to water.¹

Wet-to-dry saline gauze: A technique whereby gauze is moistened with normal saline, applied wet to the wound, and allowed to dry, then removed when adhered to the wound bed. As the dressing is removed, the wound is non-specifically debrided.¹

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APPENDIX 1: GUIDELINE METHODOLOGY

Introduction

The following methodology was used for the 2014 revision of the guideline. The methodology was circulated to all participants in the guideline development process at commencement of the project and was published on the guideline website (www.internationalguideline.com) where it was publically available throughout the guideline development period.

The methodology for this edition of the guideline was revised from 2009 with the intention of using a more rigorous process for guideline development. The inclusion criteria for research in the field was tightened in order to focus on primary evidence. A consensus voting process (GRADE) has also been added to the guideline development process in order to assign a '**strength of recommendation**' to each recommendation statement. This process is intended to provide an indication of the confidence a health professional can have that implementation of the recommendation will promote positive outcomes and can be used to prioritize interventions.

Guideline Website

<http://www.internationalguideline.com>

The international guideline website was established to publish the methodology and guideline search strategy. The website was used to make guideline sections available to stakeholders, and to collect feedback. The website platform was also used to conduct the GRADE consensus voting process.

The guideline website will be used to distribute the *Quick Reference Guideline*, acknowledge sponsors, and publish supportive documents referred to throughout this *Guideline Methodology* and will remain accessible during the interim period until the next guideline revision.

Participants

All members of the development team were screened for experience, expertise and potential conflicts of interest. In the interest of transparency, all guideline developers were asked to complete a form identifying potential conflicts of interest that covered the guideline review period. Declarations of potential conflict will be published on the guideline website.

Guideline Development Group

This second edition of the guideline was conducted by European Pressure Ulcer Advisory Panel (EPUAP), National Pressure Ulcer Advisory Panel (NPUAP) and the Pan Pacific Pressure Injury Alliance (PPPIA). The Pan Pacific Alliance consists of the Australian Wound Management Association Incorporated (AWMA), the New Zealand Wound Care Society (NZWCS), the Hong Kong Enterostomal Therapist Society and the Wound Healing Society of Singapore.

The Guideline Development Group (GDG) determined and monitored each step of the guideline development process, as well as managing guideline dissemination strategy. Each of the three partner organizations nominated four representatives each to form the 12 member GDG. From its nominated representatives, each partner organization appointed a Chair. The three partner organizations each had four votes during joint deliberations, with the majority deciding. Examination of the evidence and consensus building preceded all voting. Minority opinions were represented in meeting minutes. A full description of the GDG role is available on the guideline website.

A nonvoting observer from the Japanese Society of Pressure Ulcers (JSPU) attended GDG meetings during the 2014 revision process, with the option to join the GDG for the next revision.

Small Working Groups

The guideline content was divided into working topic areas and Small Working Groups (SWGs) were formed to review the evidence available for each topic. The SWG members were selected by each participating organization based on an experience and expertise. Representatives of industry were excluded from SWGs. The SWGs were formed based on the principle of equal contribution from all participating organizations. A full description of the SWG role is available on the guideline website. A total of 104 SWG members contributed to the guideline development process, with many members contributing to more than one SWG.

Guideline development was an iterative process, with GDG and SWG members maintaining communication via the methodologist. Evidence summaries and draft recommendations developed by the SWGs were reviewed by the GDG for:

- comprehensiveness and accuracy of literature reviews,
- methodological rigor in evidence analysis and application to clinical practice, and
- clarity and appropriateness of recommendations for an international audience.

Methodologist

The guideline process was overseen by an experienced guideline methodologist. The methodologist assisted the SWG members in implementing the documented methodology, appraising and summarizing the new literature, revising the 2009 guideline recommendation and developing new recommendations, and presenting the evidence. The methodologist also managed the confidential consensus voting process (GRADE). The methodologist provided a link between the GDG and the SWG, managing communication and maintaining progress. The methodologist attended GDG and SWG meetings, but did not participate in GDG voting.

Stakeholders

The entire process of developing the guideline was made available to stakeholders on the guideline website. A stakeholder is someone who has interest in pressure ulcers and wishes to contribute to the guideline by reading the methodology, search strategies, references under consideration, and draft recommendations, ensuring that all relevant evidence had been included and commenting on the draft guideline within the timeframes allowed. Anyone was invited to register as a stakeholder, either as an individual or as a representative for a society/organization. All members of the EPUAP, NPUAP and PPIA were invited to register as stakeholders and participate in this process.

In 2009 a total of 903 individuals and 146 societies/organizations registered as stakeholders. These stakeholders were all invited to register as stakeholders for the 2014 guideline. Additionally, patient representative organizations were also invited to participate in the stakeholder review process to provide a consumer perspective. A total of 988 individuals were formally invited to register as stakeholders, and many more received information about the process through colleagues and organizations. A total of 698 individuals registered as stakeholders to provide feedback as an individual or in representation of a society/organization.

When new sections of the guideline were made available on the guideline website, registered stakeholders were notified by electronic mail. The GDG reviewed all stakeholder comments and any additional evidence recommended by stakeholders before approving final recommendations.

Methods

The steps of the guideline development process are delineated below. For simplicity and clarity, the process is described as linear and sequential; however, the actual process was iterative, with multiple drafts developed and progressively improved based on ongoing communication among GDG members, methodologist, SWG members, and stakeholders.

Step 1: Identifying the Evidence

Databases

The GDG identified clinical questions to guide literature searches. The *Purpose and Scope*, available at the guideline website, outlines these questions in detail. To identify the scientific literature on pressure ulcer prevention and treatment, several electronic databases were consulted, including:

- PubMed
- CINAHL
- MEDLINE
- EMBASE
- Scopus
- Biomedical Reference Collection
- Health Business Elite
- The Cochrane Database of Systematic Reviews
- The Cochrane Central Register of Controlled Trials, Health Technology Assessment and AMED databases.

As the guideline builds on a previously published body of evidence, the search dates for this update were 1st January 2008 through 1st July 2013. Some SWGs, particularly those that were addressing evidence in topics newly introduced in this version of the guideline, used different inclusion dates, as per the inclusion and exclusion criteria detailed below.

Search Strategy

A sensitive search strategy was developed for the development of the guideline and made available on the guideline website. The SWGs were permitted to conduct additional focused searches to ensure the full depth and breadth of their topic area has been covered.

Inclusion and Exclusion Criteria

All references retrieved by the electronic literature search were screened by the interim methodologist (during the interim period between guideline development periods from 2009 to 2012) and by the methodologist based on the following inclusion criteria:

1. General Eligibility Criteria

Inclusion criteria:

- The articles must be primarily focused on pressure ulcer prevention, risk assessment, or pressure ulcer treatment in human subjects.
- The articles must have been published in a peer reviewed journal.
- An abstract must be available.
- The studies should have used one of the following designs:
 - randomized controlled trials (RCTs),
 - controlled clinical trials (CCTs),
 - quasi-experimental studies,
 - cohort studies,
 - cross-sectional studies,
 - survey studies,
 - prevalence or incidence studies,
 - case-control studies, and
 - case series.
- At least ten subjects must have been included in any case series.
- Systematic reviews or meta-analyses were eligible if they used the Cochrane methodology or met at

least 9 out of 11 quality criteria of the critical appraisal tool Assessment of Multiple Systematic Reviews (AMSTAR).

- SWG members reviewed, analyzed and use the original articles cited in systematic reviews and meta-analyses as the basis for guideline recommendations and systematic reviews were cited as additional supporting evidence. In order to rate the level of evidence (see step 2), the quality of the systematic review was assessed, using the AMSTAR checklist. Meta-analyses should not be equated with systematic reviews.
- Studies using established qualitative methodologies were considered, as appropriate to the research question.
- There was no restriction on the basis of the language of a study. However, studies published in languages other than English were required to indicate a high level of quality and unique data in the abstract report to warrant translation.

Exclusion criteria:

- Non-systematic literature reviews, narrative papers, opinion, commentary and descriptive papers. Papers falling into this category were used only to support expert opinion as required.
- Case series with less than 10 participants.
- Conference abstracts or other short papers with insufficient detail to enable an appraisal of the study methodology.
- Duplicate reports of research.
- Computational modeling and other research conducted in non-human subjects.
- Systematic reviews and meta-analyses that do not meet at least 9 of 11 criteria on the AMSTAR checklist.
- Papers without a substantial focus on pressure ulcer prevention or treatment or risk assessment.
- Foreign language studies for which the abstract does not indicate a high level study (i.e. at least Level 2) with unique data.

2. Eligibility Criteria for Research Reporting on Quality Improvement and Education

In addition to the criteria outlined above, additional inclusion criteria were:

- Articles with a time series design with at least three outcome measurement time points.
- Project should be institution-wide (i.e., not individual units). Projects in individual units could be covered in special population sections as appropriate (e.g., pediatrics, critical care).
- Outcomes should be incidence or facility-acquired pressure ulcer rates.
- Quality improvement projects should be described in sufficient detail to enable replication (i.e., specific methods used, barriers and facilitators).

Exclusion criteria:

- Publications before January 2008 and after December 2012 were not appraised for this guideline section.

3. Eligibility Criteria for Research Reporting on Risk Factor for Pressure Ulcers

The systematic review by Coleman et al. (2013)¹ was used as a basis for literature selection to identify patient characteristics that increase the probability of pressure ulcer development. This was supplemented by a search for literature published from 31st March 2010 to July 1st 2013.

Inclusion criteria utilised by Coleman et al. (2013)¹ were:

- Primary research.
- Outcome was the development of a new pressure ulcer(s).
- Prospective cohort, retrospective record review where the risk factor preceded the pressure ulcer or CCTs.
- Length of follow-up at least three days, with the exception of operating room studies for which no minimal time period was set.
- Outcome clearly defined as Category/Stage I or greater pressure ulcer or equivalent.
- Multivariable analyses were undertaken to identify factors affecting pressure ulcer outcome.

- The unit of analysis was the individual patient.

Exclusion criteria utilised by Coleman et al. (2013)¹ were:

- Cross-sectional, case-study, patient recall, patient self-report or analysis of general practitioner records.
- Duplicate publication of a patient dataset.
- Cohort studies (prospective and record reviews) in which more than 20% of the study sample were excluded from analysis for reasons including withdrawal, death, loss to follow-up and missing records.
- Controlled trials in which the following minimum criteria did not apply: randomised allocation to treatment and intention to treat analyses.

4. Eligibility Criteria for Research Reporting on Risk Assessment Tools

Additional inclusion criteria for papers addressing the reliability of risk assessment tools were:

- Risk assessment tools are completed by qualified health professionals.
- The research involved comparing pressure ulcer risk assessment tool scores of different raters using the same scale (interrater) or comparing pressure ulcer risk assessment tool scores of the same raters using the same scale at different times (intrarater).

The systematic review by Chou et al. (2013)² was used as a basis for literature selection related to identifying the validity of risk assessment tools. This was supplemented by literature published after the end of the review period (i.e., from 31st July 2012 to 1st July 2013).

Additional inclusion criteria for papers addressing the validity of risk assessment tools were:

- Prospective study design (i.e., RCTs, CCT, prospective cohort study).
- Reporting the evaluation of one or more risk assessment tool in the prevention of pressure ulcers (analytical methods).
- Follow-up data included on at least 75% of participants.
- Participants were aged over 18 years.
- Individuals were assessed systematically for the development of new pressure ulcers (e.g., all participants have baseline skin assessment and at follow-up intervals suitable to identify new pressure ulcers in the study population). Assessment only at baseline and discharge is not a suitable follow-up to detect all new pressure ulcers.
- Risk assessment tools are completed at baseline.
- Outcome clearly defined as development of a Category/Stage I or greater pressure ulcer.
 - Analysis methods: sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), relative risk and area under the receiver operating characteristic (AUROC) curve.

Exclusion criteria:

- Data used to generate the risk assessment tool are the same data used for the calculation of validity measures.

5. Eligibility Criteria for Research Reporting Prevalence and Incidence

Due to the vast volume of evidence relating to this new background chapter of the guideline for which literature had not previously been reviewed, a recent comprehensive publication³ was used to provide an overview of the trends in pressure ulcer prevalence and incidence. Pieper et al. (2012)³ included international pressure ulcer prevalence and incidence studies published from January 2000 to November 2011. This was supplemented by literature published after the end of the review period (i.e., from 1st November 2011 to 31st December 2012).

Studies not initially identified by bibliographic searches yet meeting these criteria were included when listed in reference lists of identified articles or recommended by SWG members or stakeholders.

Direct Versus Indirect Evidence

Studies of pressure ulcers in humans and individuals at risk of, or with existing pressure ulcers were considered 'direct evidence' and were required to support an A or B '*strength of evidence*' rating. When studies of pressure ulcers in humans at risk of, or with existing pressure ulcers were not available, studies in normal human subjects, human subjects with other types of chronic wounds, laboratory studies using animals, or computational models were used as indirect evidence to support recommendations with a C '*strength of evidence*' rating.

Step 2: Evaluating the Evidence

Appraisal of Methodological Quality

The methodological quality of each study was evaluated by two members of the SWGs. Where large discrepancy of opinion was noted (such that the paper's overall quality was rated differently by the two reviewers), a third reviewer evaluated the paper. The methodologist completed a quality check on a random sample of 80% of the critical appraisals for papers selected for potential appraisal, including those papers that the SWG assessed as not meeting inclusion criteria.

The methodological quality of each study was assessed by two reviewers using methodology checklists that were based on tools developed by the Scottish Intercollegiate Guidelines Network.⁴ Evaluation of study quality focused on the internal and external validity of the studies. The following quality criteria was considered: internal validity of the study; clear and appropriate research question(s); selection of subjects; allocation; baseline comparability; outcomes; blinding; confounding factors; statistical analysis; overall assessment of the study; and bias.

A range of critical appraisal tools were used based on different types of study design:

- Cross-sectional/survey/prevalence studies.
- Case-control studies.
- Cohort studies.
- RCTs.
- Quasi-experimental studies.
- Diagnostic studies.
- SQUIRE guideline checklist for quality improvement papers.
- Critical Appraisal Skills Program (CASP) Qualitative Research Checklist.
- AMSTAR criteria for systematic reviews.

Each criteria on the critical appraisal forms was assessed as being fully met (++), partially met (+), not met/not reported/unclear (—), or not applicable (NA). Studies were generally described as high, moderate, or low quality using the following criteria:

- High quality studies: fully met at least 80% of applicable criteria
- Moderate quality studies: partially or fully met at least 70% of applicable criteria
- Low quality studies: did not partially or fully met at least 70% of applicable criteria

Appraisal of Methodological Quality for Risk Factor Papers

In the absence of guidelines for the quality assessment of risk factor studies, Coleman et al. (2013)¹ used an assessment framework based upon guidelines for assessing quality and risk of bias in prognostic studies and methodological considerations in the analysis, meta-analysis and publication of observational studies. Each study was appraised using the method described by Coleman et al. (2013)¹ and the following factors were considered:

- Baseline characteristics are adequately described.
- Study attrition: clear definition of risk factors.
- Continuous variables used or appropriate cut-points for continuous data.
- Risk factor measurement valid and reliable.
- Method/sampling of measurement used for all individual patients.

- Appropriate imputation methods.
- Appropriate classification for outcome.
- Potential confounders accounted for in study design.
- Potential confounders accounted for in analysis.
- No selective reporting.

In addition, specific consideration will be given to the following criteria:

- Is there sufficient number of events (rule of thumb: more than 10 events per risk factor)?
- Is there sufficient presentation of data to assess the adequacy of method and analysis?
- Is the strategy for model building (i.e., inclusion of variables) appropriate and based upon a conceptual framework?
- Is the selected model adequate for the design?

Each of the above four criteria was assessed as being met (yes/no/partial/unsure) and these criteria were used as the basis of a structured approach for the classification of overall study quality. Studies were classified as high, moderate, low and very low quality using the following criteria:

- High quality studies: yes for all criteria
- Moderate quality studies: yes for criteria 1 and at least two other criteria
- Low quality studies: no for criteria 1 and no or partial for two other criteria
- Very low quality studies: no for criteria 1 and no or partial for all three remaining criteria

Level of Evidence

The '*level of evidence*' for individual intervention studies was noted for each study containing direct evidence, using a classification system adapted from Sackett (1989)⁵. A more sophisticated and complex classification systems has been developed,⁶ however, the elegant simplicity of their early work provided greater consistency when used with a large international group of reviewers.

Levels of evidence are typically applied to intervention studies (e.g., RCTs, CCTs or case series studies) because these types of studies are regarded as most important knowledge sources for clinical decision making. However, there are many more study designs (e.g., epidemiological or descriptive studies) that provide valuable evidence to guide practice, yet cannot be classified with an intervention-based level of evidence system.

Table 1: Level of Evidence for Intervention Studies

Level 1	Randomized trial(s) with clear-cut results and low risk of error OR systematic literature review or meta-analysis according to the Cochrane methodology or meeting at least 9 out of 11 quality criteria according to AMSTAR appraisal tool.
Level 2	Randomized trial(s) with uncertain results and moderate to high risk of error.
Level 3	Non randomized trial(s) with concurrent or contemporaneous controls.
Level 4	Non randomized trial(s) with historical controls.
Level 5	Case series with no controls. Specify number of subjects..

Studies on diagnostic and prognostic validity of pressure ulcer risk and pressure ulcer classification form an important body of knowledge in pressure ulcer management that should be appraised independently from intervention studies. Diagnostic accuracy studies are studies in which results of index tests are compared with results from reference standards at the same point in time.⁷ Therefore, cross-sectional designs are needed to establish the concurrent existence of both index test and reference standard results. Most studies in pressure ulcer risk research are not diagnostic accuracy studies according to this widely agreed upon definition, because the measured pressure ulcer risk is often compared with subsequent pressure ulcer

occurrence. These designs resemble those of prognostic studies or diagnostic accuracy studies with imperfect reference standards.⁸

Comparable to different phases of intervention research phases of diagnostic and prognostic research can also be distinguished. In diagnostic research, Phase I and II studies focus on differentiation between individuals with the target from those without. Phase III studies are typical diagnostic accuracy studies whereas phase IV research investigates the clinical impact of diagnostic procedures.⁹ Prognostic studies are comparable with diagnostic accuracy studies with the difference that based on factors or diagnostic cues future events are predicted. These types of studies are typically used to develop prognostic models. Prognostic models (e.g. pressure ulcer risk assessment tool scores), are used to predict the probability of future events in individuals or groups.¹⁰

Test accuracy and validity estimates are only surrogate measures for clinical effectiveness.¹¹ The clinical effectiveness of diagnostic test procedures can only be adequately investigated by diagnostic RCTs.^{12, 13} In case of diagnostic or prognostic RCTs the described level of evidence hierarchy of intervention studies is used.

Corresponding '**level of evidence**' hierarchies for diagnostic and prognostic accuracy and many other studies have been proposed^{12, 14} and have been adopted by the GDG in the guideline update.

The technical documents summarizing critical appraisals of included studies are made available at the guideline website. Permission to use the technical documents for purposes other than education can be requested at the website.

Table 2: Levels of evidence for diagnostic studies in the EPUAP-NPUAP-PPPIA guideline update^{12, 14}

Level 1	Systematic review of high quality (cross sectional) studies according to the quality assessment tools with consistently applied reference standard and blinding.
Level 2	Individual high quality (cross sectional) studies according to the quality assessment tools with consistently applied reference standard and blinding among consecutive persons.
Level 3	Non-consecutive studies, or studies without consistently applied reference standards.
Level 4	Case-control studies, or poor or non-independent reference standard.
Level 5	Mechanism-based reasoning, study of diagnostic yield (no reference standard).

Table 3: Levels of evidence for prognostic studies in the EPUAP-NPUAP-PPPIA guideline update^{12, 14}

Level 1	Systematic review of high quality (longitudinal) prospective cohort studies according to the quality assessment tools.
Level 2	A prospective cohort study.
Level 3	Analysis of prognostic factors amongst persons in a single arm of a randomized controlled trial.
Level 4	Case-series or case-control studies, or poor quality prognostic cohort study, retrospective cohort study.
Level 5	Not applicable.

Data Extraction

The full papers of selected references were obtained and made available to the relevant SWGs on a web-based (Google Docs) platform.

A data extraction template was used to extract relevant data from individual papers, including study design; description of participants; study groups and interventions; outcome measures; length of follow up; study results; and comments and limitations. Preliminary data extraction tables were prepared in the interim development period (i.e., period between the publication of the 2009 guideline and the commencement of

the 2014 guideline development period).

The members of the SWGs were provided with the preliminary data extraction tables for checking, expanding on details and adding studies that had not yet undergone data extraction. The methodologist completed a quality check of a random sample of 80% of the completed evidence tables and the GDG completed a quality check of a random sample of 10% of the completed evidence tables.

The technical documents summarizing data extraction of included studies are made available at the guideline website. Permission to use the technical documents for purposes other than education can be requested at the website.

Step 3: Drafting/Revising Recommendations

Based on the identified, appraised and summarized empirical evidence recommendations were formed. Each SWG formulated conclusions about the body of available evidence based on the evidence tables and critical appraisals and levels of evidence. Evidence tables from previous guidelines were also made available to SWGs to ensure the full body of scientific literature was reviewed. A first draft of recommendations was developed by the respective SWGs using the 2009 guideline recommendations as a guide. The GDG reviewed the draft recommendations, making revisions as necessary.

To ensure uniformity and internal consistency in the final guideline, the GDG provided the following guidance:

- Each recommendation should start with an action verb and be a simple, short, direct, declarative statement, free of jargon.
- Multiple complex recommendations should be broken down into a series of smaller, discrete recommendations.
- The SWGs were advised to start with broad, directive statements, followed by subsequent statements with more detail (how, when, how often).
- Recommendations should be specific and unambiguous.
- When available, information on health benefits, side effects and risks should be provided.
- Spelling will be based on the conventions of American English.

The GDG reviewed all recommendations to ensure the wording of the recommendations accurately translated available research into best practice while being sensitive to the many different individual cultures and professional standards represented among the international audience for these guidelines.

The term 'individual' was selected to describe the patient, client, resident, or person with a pressure ulcer or at risk for a pressure ulcer. The terms 'health professional' and 'interprofessional team' were selected for use when referring to health professionals providing professional health care services to the individual. The disciplines of professionals performing a given service may vary from country to country based on the laws and regulations governing health care providers. Products available in one country may not be available in another. Generic names were used when referring to drugs and other products.

Step 4: Assigning Strength of Evidence Ratings

'*Strength of evidence*' ratings were assigned to recommendations. This rating identifies the strength of cumulative body of evidence supporting each recommendation.

Table 4: Strength of evidence rating for each recommendation

A	The recommendation is supported by direct scientific evidence from properly designed and implemented controlled trials on pressure ulcers in humans (or individuals at-risk for pressure ulcers), providing statistical results that consistently support the guideline statement. (Level 1 studies required)
B	The recommendation is supported by direct scientific evidence from properly designed and implemented clinical series on pressure ulcers in humans (or individuals at-risk for pressure ulcers), providing statistical results that consistently support the recommendation. (Level 2, 3, 4, 5 studies)
C	The recommendation is supported by indirect evidence (e.g., studies in normal human subjects, humans with other types of chronic wounds, animal models) and/or expert opinion.

A '**strength of evidence**' rating of A required Level 1 studies conducted in individuals with pressure ulcers or at risk for pressure ulcers. This rating is consistent with recommendations derived using the Cochrane methodology. '**Strength of evidence**' ratings of B required Level 2, 3, 4, and/or 5 studies in these populations. Recommendations supported by A and B '**strength of evidence**' ratings were developed first. This strategy provided recommendations with very direct evidentiary support. Where the guideline was considered to lack the breadth and depth of guidance necessary to provide care, additional recommendations based on expert opinion and/or indirect evidence and given a '**strength of evidence**' rating of C were developed to fill the evidence gap.

The '**strength of evidence**' supporting the recommendation is not the same as the '**strength of the recommendation**'. For example, there are no RCTs in individuals with pressure ulcers that evaluate debridement compared to no debridement. Therefore, this recommendation would have a relatively low '**strength of evidence**' supporting the recommendation, yet the recommendation may be strongly recommended in many clinical situations based on evidence from studies of other types of chronic wounds, proof of principle from basic science research, and/or expert opinion. See step 6 for assigning strength of recommendations.

In this guideline, evidence gaps have been explicitly identified. Systematic literature reviews were conducted to identify indirect evidence from studies of normal subjects, studies with intermediate or surrogate outcomes, studies of humans with other types of chronic wounds, and animal studies. For many recommendations, indirect evidence may be identified to support C '**strength of evidence**' ratings. In the absence of indirect evidence, consensus from previous guidelines or expert opinion may support C '**strength of evidence**' ratings, providing a broader base of expert opinion than that available in the SWGs and GDG. The SWG members were encouraged to evaluate previous guidelines for quality using the AGREE II Tool.¹⁵ All recommendations, including those supported solely by expert opinion were reviewed by stakeholders.

Step 5: Summarizing Supporting Evidence

The SWGs summarized the evidence supporting each recommendation. An explicit link between the recommendation and supporting evidence was expected. The strengths and limitations of this body of evidence was clearly described. All recommendations with a '**strength of evidence**' rating of A or B required an explicit summary of one or more studies conducted with human subjects with pressure ulcers or at risk for pressure ulcer development. The '**level of evidence**' for each study was also identified in the summary.

The summary statements for recommendations with '**strength of evidence**' of C clarify whether the recommendation was supported by:

- indirect evidence from studies of normal subjects.
- studies with intermediate or surrogate outcomes.
- studies of humans with other types of chronic wounds, and animal studies or other basic bench research.

- expert opinion supported by previous evidence-based guidelines.
- the expert opinion of the SWG and GDG members as reviewed by international stakeholders.

Evidence gaps identified in these summary statements serve as an agenda for future research efforts, as reported by the GDG in the guideline section *Further Research Needs*.

Step 6: Assigning Strength of Recommendation Grades

As previously discussed, '**strength of evidence**' ratings identify the strength of cumulative evidence supporting the recommendation. In contrast, '**strength of recommendation**' grades require a different analysis. The recommendations are rated based on their importance and their potential to improve individual patient outcomes. The '**strength of recommendation**' is the extent to which a health professional can be confident that adherence to the recommendation will do more good than harm. The grading of importance is not necessarily related to the strength of internal or external evidence. The overall aim is to help health professionals to prioritize interventions. According to Atkins et al. (2004)¹⁶ and Guyatt et al. (2008)¹⁷ the following points should be considered to grade the strength of recommendations:

- The balance between benefits and harms. The larger the difference between both, the higher the likelihood for giving a strong recommendation.
- The overall quality of evidence across all studies upon the recommendation is based. The higher the quality, the higher the likelihood that a strong recommendation is warranted.
- Translation of the evidence into practice in specific clinical settings or uncertainty of baseline risk in the populations of interest.
- The higher the costs of an intervention, the greater the resources consumed, the lower the likelihood that a strong recommendation is warranted unless cost effectiveness can be demonstrated.

Besides overall methodological study quality and the balance between risks, harms and resources in diagnostic accuracy and prognostic studies the following additional question need to be considered for recommendation development:

- How strong is the confidence, that estimated probabilities improve clinical decision making, treatment decisions and subsequent patient outcomes?^{9, 11, 13}

The '**strength of recommendation**' grades were achieved via a formal consensus process using the GRADE grid (See *Table 5*). In this consensus process all SWG and the GDG members were invited to take part, each voting on every recommendation in the guideline. The consensus voting process (GRADE) was conducted on the website. Each guideline development team member was provided with a unique identification. Before commencing in the GRADE process, the methodology was outlined, including the considerations to be made in casting a vote. The participant was required to nominate their understanding of the procedure before commencing, or to request further information.

For each section of the guideline, the recommendation statements were presented. The participant was required to actively select to read the evidence supporting each recommendation statement, and then make a selection for a '**strength of recommendation**' grade from the options presented in *Table 5* and an additional option to abstain from voting (a reason was required). Votes were recorded and calculated using a software program designed for the purpose. Participants could nominate a '**strength of recommendation**' for as few or as many recommendations as they preferred, but were strongly encouraged to grade on all recommendations.

Table 5: The GRADE grid¹⁸ is used for establishing consensus for every recommendation






Balance btw desirable & undesirable consequences	Desirable clearly outweigh undesirable	Desirable probably outweigh undesirable	Trade-offs equally balanced or uncertain	Undesirable probably outweigh desirable	Undesirable clearly outweigh desirable
Recommendation example	Strong: definitely do it	Weak: probably do it	No specific recommendation	Weak: probably don't do it	Strong: definitely don't do it
'Use structured approach to risk assessment'	" "	" "	" "	" "	" "
'Limit head-of-bed elevation to 30°'	" "	" "	" "	" "	" "

Rules were determined based on previous applications of the GRADE process,¹⁶⁻¹⁸ and a desire to obtain significant consensus. Determination of the final '**strength of recommendation**' was made according to the following rules:

- To achieve a strong positive (do it) or strong negative (don't do it) recommendation, 100% of votes must be cast in the same direction (positive or negative), with at least 70% voting for a strong recommendation, and 0% voting in the opposite direction.
- To achieve a weak positive (probably do it) or weak negative (probably don't do it) recommendation, at least 70% of votes must cast in the same direction (positive or negative), and less than 20% voting in the opposite direction.
- Any other combination of voting results in 'no specific recommendation'.

This resulted in five potential '**strengths of recommendation**' (see table 6).

Table 6: Five types of recommendations¹⁶⁻¹⁸ are used in this guideline

Recommendation	Symbol	Description	Implications
Do it (Strong recommendation for using an intervention)		Indicates a judgment that most well informed people would make.	<i>For patient consumers</i> —Most people would want the recommended course of action and only a small proportion would not. <i>For health professionals</i> —Most people should receive the intervention. If health professionals choose not to follow the recommendation, they should document their rationale.
Don't do it (Strong recommendation against using an intervention)			<i>For quality monitors</i> —Adherence to this recommendation could be used as a quality criterion or performance indicator.
Probably do it (Weak recommendation for using an intervention)		Indicates a judgment that a majority of well informed people would make, but a substantial minority would not.	<i>For patient consumers</i> —Most people would want the suggested course of action, but many would not.
Probably don't do it (Weak recommendation against using an intervention)			<i>For health professionals</i> —Examine, and be prepared to discuss, the evidence with patients, as well as their values and preferences. <i>For quality monitors</i> —Clinicians' discussion and consideration of pros and cons of the intervention, and documentation of discussion, could be used as a quality indicator.
No specific recommendation		Trade-offs between risk and benefit unclear or lack of agreement between voting participants.	The advantages and disadvantages are equivalent; and/or the target population has not been identified; and/or there is insufficient evidence on which to formulate a strength of recommendation.

Final Review and Recommendations

The GDG was integrally involved in each of these steps. Following review and approval of individual recommendations, the methodologist and the GDG reviewed all guideline documents for internal consistency, logical coherence and adherence to the guideline methodology. Based on this final review, the GDG will provide a global assessment of the strengths and limitations of the body of evidence supporting the guideline and recommendation for future research.

The GDG will continue to monitor guideline implementation after the guideline is published, encouraging translation of the guideline into non-English languages for maximum dissemination. The 2009 guideline was translated into 17 different languages.

To facilitate application of the guideline, a SWG was established to review existing quality and safety literature addressing common facilitators and barriers to guideline implementation and to make recommendations to support implementation. These recommendations are outlined in the guideline section, *Implementing the Guideline: Facilitators, Barriers and Implementation Strategy*. Health professionals are encouraged to use the ADAPTE Tool¹⁹ in adapting this guideline for specific populations and settings.

Additionally, a SWG was established to review the recommendations in the guideline and identify quality indicators that could be used to monitor the implementation of this guideline. A wide range of clinical indicators are currently used around the world as part of ongoing health service accreditation programs, international benchmarking projects and at local levels for monitoring ongoing quality improvement. The quality indicators identified in the guideline section *Implementing the Guideline: Quality Indicators* are designed to monitor the specific recommendations for practice that are included in this guideline. They were selected based on expert opinion on their intrinsic value as an indicator of quality care for prevention and treatment of pressure ulcers and their '**strength of recommendation**', with consideration to practicalities of ongoing auditing. The indicators are proposed for use in health facilities/services in addition to other quality indicators as a measure of effectiveness in implementing the guideline locally.

The GDG will continue to monitor the pressure ulcer literature after the 2014 guideline has been published. Another revision is planned for 2019 (or sooner, if ongoing literature reviews reveals major advances in pressure ulcer prevention and treatment prior to 2019).

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