# The Breadth of Hospital-Acquired Pneumonia: Nonventilated versus Ventilated Patients in Pennsylvania

*James Davis, BSN, RN, CCRN, CIC*
*Senior Infection Prevention Analyst*
*Edward Finley, BS*
*Data Analyst*
*Pennsylvania Patient Safety Authority*

## ABSTRACT

*Considering the evolution of measures designed to prevent nosocomial pneumonia, it makes clinical and financial sense to focus efforts on patients who require mechanical ventilation. Patients at risk for ventilator-associated pneumonia (VAP) are easily identified because they require an endotracheal tube or tracheostomy, require life support, and are commonly admitted to specific areas of the hospital. However, Pennsylvania data reveals that mortality rates for patients with nonventilator-hospital-acquired pneumonia (NV-HAP) are comparable to mortality rates for patients with VAP. Using Pennsylvania data, Pennsylvania Patient Safety Authority analysts have also determined that NV-HAP affects more people than VAP and is as lethal as and more costly than VAP. Furthermore, NV-HAP is a safety issue that is on the rise in patients in the conventional ward, and it is likely to be underreported. Data suggests that if VAP prevention is a focus at a facility, perhaps NV-HAP prevention should also share the spotlight. (Pa Patient Saf Advis 2012 Sep;9[3]:99-105.)*

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## INTRODUCTION

Hospital-acquired pneumonia (HAP), according to the Centers for Disease Control and Prevention (CDC), "has accounted for approximately 15% of all hospital-associated infections."[1] HAP taxonomy separates event cases into those patients requiring mechanical ventilation and those who do not require ventilator support. A patient receiving mechanical ventilation who is confirmed to have nosocomial pneumonia while on the ventilator is classified as having ventilator-associated pneumonia (VAP). For the purpose of this article, a patient who develops nosocomial pneumonia and is not ventilated is classified as having nonventilator-HAP (NV-HAP). The most recent CDC guideline for preventing HAP identifies that "the primary risk factor for the development of hospital-associated bacterial pneumonia is mechanical ventilation."[1] The CDC guideline stated that some reports showed that "patients receiving continuous mechanical ventilation had 6-21 times the risk of developing hospital-associated pneumonia compared with patients who were not receiving mechanical ventilation."[1] Furthermore, CDC identified that "because of this tremendous risk, in the last two decades, most of the research on hospital-associated pneumonia has been focused on VAP."[1] Literature highlighting incidence and outcome data with regard to NV-HAP is sparse. Esperatti et al. hypothesized that this lack of data "may be caused in part by the dispersion of cases within hospital wards, hindering surveillance."[2]

## BACKGROUND

Considering the evolution of measures designed to prevent nosocomial pneumonia, it makes clinical and financial sense to focus efforts on patients who require mechanical ventilation. Patients at risk for VAP are easily identified because they require an endotracheal tube or tracheostomy, require life support, and are commonly admitted to specific areas of the hospital. The intensive care unit (ICU) is one such care area where resources, such as specially trained staff, ventilators, and interventions, could be matched to patient needs.

The CDC provides a surveillance definition for VAP and modules in the National Healthcare Safety Network (NHSN) that enable VAP infection tracking. Standardized surveillance case definitions and a searchable national database provide information for calculating the projected costs of VAP. Therefore, VAP is an identifiable, trackable, fiscally measurable target with evidence-based preventive care bundles that can be applied with focused resources. The Institute for Healthcare Improvement states that "many hospitals have achieved significant reductions in VAP rates in their critical care units, some even reaching zero by taking a comprehensive and multidisciplinary approach to ventilator care."[3] Pennsylvania hospitals have shown impressive VAP rate reductions with the adoption of the adult VAP bundle and innovation by way of developing evidence-based practices in the form of neonatal and pediatric VAP prevention bundles.[4] Literature suggests that VAP bundles positively impact VAP infection rates; however, VAP is not the only piece in the nosocomial pneumonia puzzle.

## METHODS

Pennsylvania state law requires that all healthcare-associated infections are reported through NHSN. Pennsylvania Patient Safety Authority analysts queried NHSN for complete nosocomial pneumonia data sets from calendar years 2009 through 2011, inclusive of the total inpatient population for Pennsylvania acute care facilities. Analysts also extracted data for nosocomial pneumonia that contributed to death during that same time period. Of those cases in which nosocomial pneumonia contributed to death, ventilator status was also extracted. Time series data was aggregated into yearly subtotals and a final total for analysis.

Table 1. Pennsylvania Nosocomial Pneumonia and Related Deaths

| YEAR | NO. OF NV-HAP CASES | NO. OF NV-HAP DEATHS | % OF NV-HAP CASES CONTRIBUTING TO DEATH | NO. OF VAP CASES | NO. OF VAP DEATHS | % OF VAP CASES CONTRIBUTING TO DEATH |
|---|---|---|---|---|---|---|
| 2009 | 1,976 | 363 | 18.4 (95% CI: 16.5 to 20.3) | 922 | 163 | 17.7 (95% CI: 15.0 to 20.5) |
| 2010 | 1,848 | 366 | 19.8 (95% CI: 17.8 to 21.8) | 737 | 144 | 19.5 (95% CI: 16.3 to 22.7) |
| 2011 | 1,773 | 315 | 17.8 (95% CI: 15.8 to 19.7) | 640 | 127 | 19.8 (95% CI: 16.4 to 23.3) |
| **Total** | **5,597** | **1,044** | **18.7 (95% CI: 17.5 to 19.8)** | **2,299** | **434** | **18.9 (95% CI: 17.1 to 20.7)** |

*Note*: NV-HAP refers to nonventilator-hospital-acquired pneumonia and VAP refers to ventilator-associated pneumonia.

## RESULTS

Table 1 shows the number of NV-HAP and VAP cases for 2009, 2010, and 2011 from NHSN, with the total for all three years. Also included in the table is the yearly and combined totals for deaths related to either VAP or NV-HAP. Table 1 also depicts the percentage of patients for which NV-HAP or VAP contributed to their deaths. Comparing the data year to year, considering the confidence intervals, there were no statistically significant differences between the two groups. The mortality rates for patients with NV-HAP and VAP were comparable.

NV-HAP has the potential to be more costly than VAP. Table 2 depicts a comparison of the estimated costs for VAP and NV-HAP cases[5] over three years in Pennsylvania.

## DISCUSSION

As previously noted,[1] the majority of knowledge related to HAP has focused on VAP. VAP is an important subset of HAP; however, if the hypothesis noted by Esperatti et al. is valid, the true incidence of NV-HAP may be underestimated. In a multicenter study of NV-HAP in patients cared for outside of the ICU, Sopena and Sabrià realized that the number of patients with nosocomial pneumonia is increasing in the conventional hospital ward.[6] Werarak et al. noted in their study that the differences in outcomes related to NV-HAP and VAP are not significant; however, NV-HAP patients did experience hypoxic episodes more often than patients with VAP.[7] Their apparent observation is important given the potential damage repeated hypoxic episodes may have on a patient's well-being. Because NV-HAP is on the rise in patients cared for in the conventional ward and tends to be underreported, NV-HAP may become more costly if prevention efforts continue to focus largely on VAP.

### Etiology of HAP

*Major factors* that increase the patient's risk for pneumonia include aspiration, stroke (because of impaired swallowing function or diminished gag reflex), older age, altered level of consciousness (for example, due to medications, substance abuse, or seizure), gastroesophageal reflux disease, and poor oral hygiene.[8] For infection to occur, several conditions need to occur in succession. These conditions are referred to as the *chain of infection*.[9] Those conditions needed to complete the chain of infection include the following:

1. Pathogen in sufficient numbers (dose)
2. Pathogen of sufficient virulence
3. Susceptible host
4. Mode of transmission or transfer of the pathogen from source (reservoir) to host
5. Portal of entry into the host

*Major risk factors* for pneumonia understandably allude to the oronasopharynx, oral cavity, and maintenance of functional, chemical, and mechanical safeguards against pathogen invasion. Part of the pathogenesis of HAP involves the oral cavity as a source and reservoir for bacteria that may then cause systemic disease. Li et al. noted that "the teeth are the only nonshedding surfaces in the body, and bacterial levels can reach more than $10^{11}$ microorganisms per mg of dental plaque."[10] The presence of subgingival biofilm serves as a continual and enormous bacterial load.[10]

Pathogenic organisms in the oropharynx may be endogenous or exogenous. Endogenous pathogens may be present secondary to the patient's dental state, underlying comorbidities, or overgrowth from recent antibiotic use. Exogenous pathogens may be present from the patient's native environment, the hospital environment, or medical devices (such as suction catheters and endotracheal tubes [ETTs]) and due to inadequate hand hygiene, cross-contamination, or translocation. Poor oral hygiene increases plaque load, which increases the level of enzymes in saliva.[10] Furthermore, an increased presence of oral proteolytic enzymes may change the lining of the mouth, increasing attachment and colonization by exogenous or endogenous pathogenic bacteria.[11]

For a host to be susceptible, immunity needs to be adversely affected. Interrupting the first line of human defense to bacterial invasion may result in significant insult that could easily lead to HAP. Mechanical defenses include an intact, moist, and healthy oral lining and mucosa. Healthy, intact oral epithelial

Table 2. Estimated Costs of NV-HAP and VAP Cases

| YEAR | NO. OF NV-HAP CASES | COST FOR NV-HAP CASES | NO. OF VAP CASES | COST FOR VAP CASES |
|---|---|---|---|---|
| 2009 | 1,976 | $55,343,808 | 922 | $34,521,524 |
| 2010 | 1,848 | $51,758,784 | 737 | $27,594,754 |
| 2011 | 1,773 | $49,658,184 | 640 | $23,962,880 |
| **Total** | **5,597** | **$156,760,776** | **2,299** | **$86,079,158** |

*Note:* NV-HAP refers to nonventilator-hospital-acquired pneumonia and VAP refers to ventilator-associated pneumonia. The estimated average cost per NV-HAP case is $28,008. The estimated average cost per VAP case is $37,442. Average costs derived from the following study: Kalsekar I, Amsden J, Kothari S, et al. Economic and utilization burden of hospital-acquired pneumonia (HAP): a systematic review and meta-analysis. *Chest* 2010 Oct;138(4_MeetingAbstracts):739A.

cells not only provide a physical barrier against infection but are capable of mediating a chemical response to the invasion of pathogenic bacteria.[12] Functional cilia in the nares and healthy mucosa help limit intrusion of inhaled potential pathogens from entering the airway. The presence of an intact cough and gag reflex also protects the patient from aspiration of oral contents into the lungs. Given the list of major risk factors for HAP, one can easily realize how the innate immune system may be compromised in an at-risk patient. Therefore, patients at risk for HAP are susceptible hosts.

The mode of transmission has been partially explained during the discussion of oral colonization of potential pathogens and biofilm as a constant reservoir. The bacteria are transferred from the oral cavity into the lungs because of lapses in basic host defenses. In VAP cases, the internal and external lumens of the ETT or tracheostomy tube may become covered in biofilm contributing to bacterial transfer as well as aspiration of subglottic secretions containing bacteria derived from oral plaque biofilm. The portal of entry into the host is the oral cavity, the aerodigestive tract, and the ETT or tracheostomy tube, if present, thereby completing the chain to HAP.

## Oral Hygiene

During a systematic literature review, Scannapieco et al. noted a 40% decrease in HAP with combined interventions that included mechanical or topical chemical disinfection (or both) or topical oral antibiotic use.[13] Paju and Scannapieco state that "institutionalized but non-ventilated patients . . . appear to benefit from improved oral care by showing lower levels of oral bacteria and fewer pneumonia episodes and febrile days."[14] A statistically significant difference ($p = 0.044$) in oral hygiene index (OHI) scores among individuals with respiratory disease and those with no disease has been noted by Scannapieco et al.[15] Furthermore, individuals with median OHI scores are 1.3 times as likely to have respiratory disease, and those with maximum OHI scores are 4.5 times as likely to have respiratory disease.[15]

## The Dental Professional

Healthcare settings depend on teamwork to drive positive patient outcomes; a multidisciplinary approach for planning care is essential for delivering effective complex care. A multidisciplinary approach is also essential for preventing complications associated with exposure to the healthcare setting, such as HAP. Adachi et al. correlated weekly dental cleaning by a hygienist with less fever and fatal pneumonia.[16] In a similar study, Abe et al. noted a reduction in influenza infection related to weekly professional dental cleaning.[17]

Just as a cardiologist is consulted to care for a patient with an underlying heart condition even though a cardiac condition may not be the primary reason for admission, a cardiologist's expertise is utilized to plan treatment and preventive care. The same line of reasoning holds true for those who practice medical and surgical dentistry and for the registered dental hygienist. The dental professional may be a missing link in the chain of HAP prevention.

# NV-HAP PREVENTION STRATEGIES

## Plotting a Course

VAP was discussed as a logical place to start the battle against HAP; however, NV-HAP requires a different approach. The population of patients who may develop NV-HAP could prove to be quite large—are there focal points for implementing preventive measures? To assist the clinician in focusing efforts on care areas, Authority analysts looked to the data. Table 3 provides a view of NV-HAP by NHSN location type for Pennsylvania, by pooled mean and percentiles. This table is presented in a format similar to an NHSN report. The Authority analysts chose to use patient-days as the unit-specific denominator for the development of this analysis. The Authority's choice of denominator was limited by the constraints of available data. Analysis by patient-days may *underestimate* the true rate of NV-HAP since this metric potentially lowers rates in regard to extensions of length of stay related to NV-HAP. Authority analysts did not have access to unit-level specific admissions by location type for this analysis, hence the use of patient-days by location type. Rates in Table 3 are reflected as per 1,000 patient-days.

## Targeted Intervention

After a patient population or unit is identified at the facility level, proven interventions and lessons derived from VAP prevention activities can be applied to the NV-HAP patient. Selected interventions from the literature that may be applicable to the NV-HAP population are reflected in the Figure.

*(continued on page 105)*

Table 3. Distribution of NV-HAP Cases (based on aggregate data for Pennsylvania for 2009, 2010, and 2011)

| UNIT TYPE* | NO. OF LOCATIONS | NO. OF NV-HAP CASES | PATIENT-DAYS | POOLED MEAN†,‡ | PERCENTILE‡,§ | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10% | 25% | (Median) 50% | 75% | 90% |
| **Critical Care** | | | | | | | | | |
| Neurologic | 3 | 11 | 40,512 | 0.272 | | | 0.247 | | |
| Cardiothoracic | 33 | 216 | 930,991 | 0.232 | 0.062 | 0.133 | 0.210 | 0.363 | 0.484 |
| Surgery | 16 | 154 | 670,509 | 0.230 | 0.040 | 0.121 | 0.210 | 0.330 | 0.459 |
| Trauma | 11 | 107 | 515,252 | 0.208 | 0.153 | 0.183 | 0.207 | 0.286 | 0.319 |
| Medical/surgical | 137 | 848 | 4,480,656 | 0.189 | 0.000 | 0.051 | 0.123 | 0.249 | 0.449 |
| Neurosurgical | 8 | 85 | 454,838 | 0.187 | | | 0.139 | | |
| Cardiac | 29 | 131 | 927,286 | 0.141 | 0.000 | 0.038 | 0.109 | 0.195 | 0.330 |
| Medical | 31 | 190 | 1,364,397 | 0.139 | 0.016 | 0.056 | 0.099 | 0.246 | 0.347 |
| Burn | 4 | 7 | 82,443 | 0.085 | | | 0.082 | | |
| Respiratory | 2 | 4 | 65,637 | 0.061 | | | 0.080 | | |
| Cardiothoracic pediatric | 3 | 8 | 180,915 | 0.044 | | | 0.000 | | |
| Nursery | 24 | 25 | 1,049,229 | 0.024 | 0.000 | 0.000 | 0.000 | 0.022 | 0.071 |
| Medical/surgical pediatric | 6 | 7 | 343,164 | 0.020 | | | 0.004 | | |
| **Ward** | | | | | | | | | |
| Genitourinary | 3 | 12 | 124,972 | 0.096 | | | 0.110 | | |
| Neurologic | 9 | 39 | 410,219 | 0.095 | | | 0.078 | | |
| Pulmonary | 4 | 32 | 359,703 | 0.089 | | | 0.071 | | |
| Neurosurgical | 8 | 27 | 354,410 | 0.076 | | | 0.075 | | |
| Surgical | 48 | 312 | 4,209,299 | 0.074 | 0.000 | 0.037 | 0.069 | 0.113 | 0.168 |
| Vascular surgery | 2 | 5 | 70,231 | 0.071 | | | 0.060 | | |
| Medical/surgical | 152 | 1673 | 23,904,085 | 0.070 | 0.000 | 0.018 | 0.052 | 0.096 | 0.158 |
| Medical | 58 | 507 | 8,064,412 | 0.063 | 0.000 | 0.019 | 0.035 | 0.070 | 0.116 |
| Orthopedic | 50 | 133 | 2,145,512 | 0.062 | 0.000 | 0.000 | 0.044 | 0.093 | 0.186 |
| Gynecology | 8 | 3 | 157,176 | 0.019 | | | 0.000 | | |
| Gerontology | 2 | 2 | 118,333 | 0.017 | | | 0.023 | | |
| Behavioral | 110 | 90 | 8,258,652 | 0.011 | 0.000 | 0.000 | 0.000 | 0.015 | 0.075 |
| Medical pediatric | 4 | 5 | 472,100 | 0.011 | | | 0.002 | | |
| Orthopedic pediatric | 3 | 1 | 95,976 | 0.010 | | | 0.000 | | |
| Nursery | 79 | 10 | 1,362,609 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Table 3. Distribution of NV-HAP Cases (based on aggregate data for Pennsylvania for 2009, 2010, and 2011) (continued)

| UNIT TYPE* | NO. OF LOCATIONS | NO. OF NV-HAP CASES | PATIENT-DAYS | POOLED MEAN†,‡ | PERCENTILE‡,§ | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10% | 25% | (Median) 50% | 75% | 90% |
| Behavioral health pediatric | 12 | 2 | 302,401 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 |
| Postpartum | 63 | 12 | 1,944,665 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.026 |
| Rehabilitation pediatric | 5 | 1 | 176,551 | 0.006 | | | 0.069 | | |
| Medical/surgical pediatric | 44 | 5 | 959,543 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Behavioral health adolescent | 11 | 2 | 417,412 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.014 |
| Labor & delivery/ postpartum | 43 | 4 | 837,294 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Labor & delivery | 22 | 1 | 426,176 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rehabilitation | 82 | 163 | 5,649,493 | 0.029 | 0.000 | 0.000 | 0.020 | 0.062 | 0.128 |
| **Specialty Care Area** | | | | | | | | | |
| Bone marrow transplant | 5 | 33 | 291,857 | 0.113 | | | 0.133 | | |
| Hematology/ oncology | 16 | 172 | 1,905,141 | 0.090 | 0.000 | 0.025 | 0.063 | 0.110 | 0.192 |
| Solid organ transplant | 1 | 2 | 24,645 | 0.081 | | | 0.081 | | |
| Hematology/ oncology pediatric | 4 | 13 | 297,827 | 0.044 | | | 0.024 | | |
| Solid organ transplant pediatric | 1 | 1 | 83,559 | 0.012 | | | 0.012 | | |
| **Step-Down Unit** | | | | | | | | | |
| Adult | 73 | 379 | 5,332,998 | 0.071 | 0.000 | 0.010 | 0.046 | 0.102 | 0.156 |
| Nursery | 23 | 12 | 484,825 | 0.025 | 0.000 | 0.000 | 0.000 | 0.044 | 0.114 |
| Pediatric | 4 | 2 | 190,271 | 0.011 | | | 0.010 | | |
| **Long-Term Acute Care** | | | | | | | | | |
| | 28 | 117 | 2,688,812 | 0.044 | 0.000 | 0.000 | 0.020 | 0.073 | 0.122 |

*Note:* NV-HAP refers to nonventilator-hospital-acquired pneumonia. Locations that are not represented reported no events.

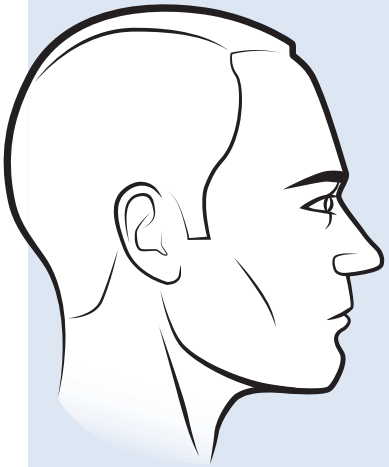
* Units are based on National Healthcare Safety Network classifications.

† Pooled mean = total infections ÷ total patient-days x 1000

‡ Per 1000 patient-days

§ For locations that have less than 10 units, reporting percentile distributions have not been calculated.

Figure. Selected Interventions to Prevent Nonventilator-Hospital-Acquired Pneumonia

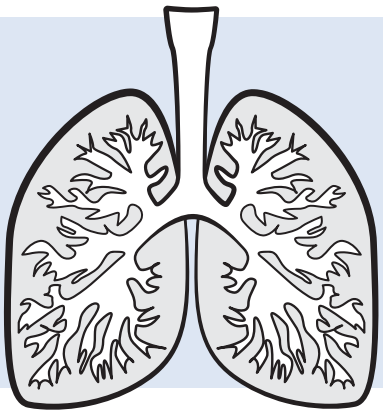


## Selected interventions to prevent colonization:

- Provide information about optimal pulmonary state.
- Optimize functional reserve capacity.
- Strengthen patient's resistance to atelectasis.
- Maintain patient's resistance to infection:
  - Perform hand hygiene.
  - Institute a routine oral hygiene regimen.
  - Eliminate oral bacterial reservoirs.
  - Consult with a dental professional.
  - Protect oral epithelial cells and nasal passages by providing moisture and avoiding large-bore nasogastric tubes.
  - Avoid unnecessary antibiotics.
  - Avoid unnecessary stress ulcer prophylaxis (if necessary, consider a cytoprotective agent).
  - Consider chlorhexidine oral rinse or chlorhexidine bath for select patient populations.

## Selected interventions to prevent aspiration:

- Teach techniques for optimizing cough and airway clearance.
- Avoid unnecessary medications that reduce level of consciousness.
- Maintain head of the bed at 30 degrees or greater unless contraindicated.
- Encourage ambulation.
- Provide subglottic suctioning.
- Consult with speech and/or swallowing professionals when appropriate.



## Holistic prevention strategies:

- Administer vaccines and immunizations.
- Provide smoking cessation counseling.
- Institute environmental infection control measures.
- Encourage personal hygiene, including hand hygiene.
- Evaluate the patient's risk for aspiration.
- Provide dementia screening.
- Assess the patient's nutritional status.
- Encourage routine professional dental care.

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*Notes*

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*(continued from page 101)*

## CONCLUSION

The chain of infection that perpetuates HAP can be broken with appropriate interventions. In the case of VAP, the majority of interventions are aimed at reducing the risk for aspiration, decolonizing the oral cavity, maintaining the aerodigestive tract, and protecting the mouth. Furthermore, if oral hygiene is compromised, the oral cavity and nasopharyngeal tract will serve as a constant reservoir of pathogens.

Currently, NV-HAP bundles are lacking in the peer-reviewed literature. Focusing care on reservoirs and the portal of entry may be the most realistic approach for preventing NV-HAP at this time. Improving oral hygiene and collaborating with a dental professional may prove essential in preventing NV-HAP (and VAP). NV-HAP in Pennsylvania may potentially have a greater impact than VAP. If VAP prevention is a focus at a facility, perhaps the prevention of NV-HAP—which has the potential to affect more patients, be more costly, and be as lethal as VAP—deserves to share the spotlight.

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## THE PENNSYLVANIA PATIENT SAFETY AUTHORITY AND ITS CONTRACTORS

PATIENT SAFETY AUTHORITY
An Independent Agency of the Commonwealth of Pennsylvania

The Pennsylvania Patient Safety Authority is an independent state agency created by Act 13 of 2002, the Medical Care Availability and Reduction of Error ("Mcare") Act. Consistent with Act 13, ECRI Institute, as contractor for the Authority, is issuing this publication to advise medical facilities of immediate changes that can be instituted to reduce Serious Events and Incidents. For more information about the Pennsylvania Patient Safety Authority, see the Authority's website at http://www.patientsafetyauthority.org.

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ISMP
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The Institute for Safe Medication Practices (ISMP) is an independent, nonprofit organization dedicated solely to medication error prevention and safe medication use. ISMP provides recommendations for the safe use of medications to the healthcare community including healthcare professionals, government agencies, accrediting organizations, and consumers. ISMP's efforts are built on a nonpunitive approach and systems-based solutions.

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