

COVID-19 preparedness within the surgical, obstetric and anaesthetic ecosystem in Sub Saharan Africa

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COVID-19 cases rapidly spread from East Asia through Europe and North America, and are now a growing threat in Africa(1)(2)(3). Early modelling studies project enormous resource challenges for countries that are already stretched thin, and whose capacities are currently not capable of providing minimum surgical service needs for their populations(4)(5). As this pandemic grows, hospitals must ensure continued provision of emergency and essential surgery and obstetric care. At the same time, hospitals risk increasingly becoming sources of infection and transmission, both amongst patients and to health care workers; hospitals must take appropriate steps to minimize onward transmission(6)(7). In Sub-Saharan Africa, where the health care workforce is already insufficient, human and physical resources will be rapidly overwhelmed and providers at very high risk. Furthermore, as is already happening in well-resourced contexts, consumables and disposables will also be critically inadequate.

Surgical, obstetric and anaesthetic care is an integral part of any health system, and the acuity, skill sets, resources and supply chains that support such services will be essential for responding to the impending crisis. Operating theatres are potentially high exposure zones given manipulation of the airway and aerosolization of respiratory particles, with anaesthesia providers at particularly high risk. It comes with the additional risk inherent in the presence of multiple staff members – surgeons, anaesthesia providers, nurses, and cleaners – who are all involved in managing perioperative processes. Anaesthesiologists are also frequently responsible for managing intensive care units. Thus, the exposure, and subsequent nosocomial and community transmission potential, is an extraordinary risk.

In order to prepare for the increasing arrival of COVID-19 patients in low-resource nations in Africa and elsewhere, surgical systems within hospitals can prepare by applying lessons learned in other settings while recognizing the realities of current resource constraints. It is necessary to act immediately so as to prepare facilities to support ongoing essential surgical care as much as possible while protecting patients and staff and conserving valuable resources (8)(9).

1. Develop a clear plan for providing essential operations during the pandemic(9).

While many highly-resourced environments have indefinitely postponed elective operations to preserve vital resources including hospital beds and personal protective equipment(10), this approach is not as applicable in many facilities within sub-Saharan Africa. The American College of Surgeons has recently proposed a schema to help with triage decision making for elective cases: <https://www.facs.org/about-acsc/covid-19/information-for-surgeons/triage>. Many operations in the region are for cancer or highly symptomatic patients, and as such the current guidance is not to postpone. It is important to recognize that decisions are fluid, and each hospital must make them based on current availability of resources and good clinical judgement.

Truly elective operations should, however, be postponed immediately as this will help preserve the health and wellbeing of surgical, anaesthetic, nursing, and cleaning staff. These providers will all be important resources during a surge response at a hospital. It is essential to note that this may be particularly difficult for surgical and anaesthetic providers, as many of them rely on elective and private work for their financial well-being. Thus, postponing elective surgery may work against their financial incentives. Health ministries must recognize this as they plan for a pivot in health service provision. However, improved health worker and patient safety through reduced transmission is a compelling enough argument. To facilitate decision making and avoid conflicts between patients and providers, a triage algorithm for identification non-emergent conditions can be used.

While elective lists might be postponed, surgical emergencies still require prioritization; in many settings this is already strained and very challenging. Clear triage algorithms and protocols need to be established and enforced, and surgical capacities preserved. This should include funding to support the hospital and staff with critical surgical services that will continue to be required despite the pandemic response. Consider trialing nonoperative management for certain surgical conditions such as appendicitis and cholecystitis when safe for patients. One of the most challenging decisions could be surgical and gynaecologic oncology cases: individualized decision making should be done with involvement of the most experienced staff and patient's informed consent. Furthermore, there

must be consideration and planning for how such patients can be kept geographically separate from COVID+ patients, and how they can be rapidly discharged to prevent nosocomial transmission(11)(12)(13)(14). If case burden is high, consider dedication of one operating theatre to COVID+ operations only. Operating theatres for COVID+ patients should be kept at neutral or negative pressure rather than the typical positive pressure environment (15).

2. Decrease exposure of health care staff as much as practicable.

Few staff are adequately trained in the appropriate use and application of PPE. However, perioperative personnel are at an advantage given their familiarity with maintaining sterility. Staff should receive training in the appropriate donning and doffing of PPE taught through simulation and videos (i.e. without using precious resources). The use of two providers for PPE donning and doffing procedures should be encouraged, to allow one person to observe and coach the other through the steps of the routine (16)(17)(18)(19)(20)(21)(22). While the specifics of PPE are beyond the scope of this paper, we refer you to several resources for describing appropriate PPE and the procedures for donning and doffing PPE: www.cdc.gov/hai/pdfs/ppe/ppe-sequence.pdf (17)(23). A repository of healthcare training resources specific to COVID-19 is also available through the NIH: <https://tools.niehs.nih.gov/wetp/covid19worker/>.

Any additional patients or family members moving through the hospital increases patient traffic and adds to the exposure risk. Limiting unnecessary patient movement through the hospital decreases the introduction and transmission of disease between symptomatic and asymptomatic patients, their families, and health care staff.

Health workers are being affected in large numbers. Fundamental hygiene practices are essential for everyone: wash your hands frequently, use alcohol-based hand rub, and stop shaking hands; avoid touching your eyes, nose, and mouth; stay home when you are sick; cough or sneeze into your elbow (or a tissue, then throw it away); and disinfect frequently touched objects and surfaces. For usual care routines not involving the airway, the use of surgical masks has been associated with

decreased transmission and lower rates of health care worker infections, and is recommended(24)(25). Furthermore, limiting operating theatre staff to essential members will help preserve the surgical workforce. Trainees and students, in particular, should not be involved with known COVID-19 positive cases unnecessarily.

When not vital to the effort, keep surgical and anaesthetic staff out of hospital and self-isolating at home to preserve human resources. This will also allow personnel to rest before they return to clinical work. Furthermore, ancillary staff such as OR cleaners, instrument reprocessing staff and laundry personnel should take appropriate precautions and wear PPE (goggles or face shield, surgical mask, heavy duty gloves, long sleeved gown, boots) to avoid exposure to contaminated materials(9). No special decontamination methods other than machine laundering with detergent are required for laundering linens; all surface areas should be disinfected with 0.5% chlorine or 70% alcohol solutions.

3. Prevent transmission of the SARS-CoV-19 coronavirus to other patients and personnel.

Wash your hands! Hand sanitizer should be made widely available; the World Health Organization has published guidance on making alcohol-based hand rub that most facilities should be able to perform: https://www.who.int/gpsc/5may/Guide_to_Local_Production.pdf. Symptomatic workers should not provide patient care but rather self-isolate.

Develop care pathways and protocols for COVID+ patients, including the identification of dedicated team members to manage COVID-19 cases each day. Establish a dedicated COVID-19 operating space if practicable, recognizing that many facilities may have very limited numbers of operating theatres. This should be emptied of all non-essential materials and equipment. Clear instructional posters for PPE donning/doffing should be prominently displayed (23)(17). In addition, a taped off area just outside of the OR door should be clearly marked for donning and doffing activities. No unnecessary items should be brought into the operating theatre, including personal items such as mobile phones and pens. Personal linens and coverings such as cloth masks and bonnets should

be washed at least daily, and probably more often if treating known COVID+ patients. Traffic should be minimized, especially opening and closing of theatre doors(9).

Patients with known or suspected COVID-19 infection should wear surgical masks when being transported through hospital spaces or in rooms without negative pressure isolation(26)(27)(28). Intubation is an aerosolizing procedure and should be performed by the most skilled provider available. When appropriate and safe consider regional anaesthesia with IV sedation rather than general anaesthesia to reduce aerosols. During intubation, airborne precautions should be taken through the use of an N95 mask or powered air-purifying respirator (PAPR) in addition to contact PPE; *only absolutely essential staff* should be present in the operating theatre. IV rapid sequence induction without bag mask ventilation is preferred to minimize exposure risks and aerosolization; the use of deeper sedation extubation to prevent coughing is also preferable as long as the airway is safe. Patients should be recovered in the operating theatre, and prior to transport the path of the patient to and from the operating theatre and ward should be kept clear using an advance runner to clear the way. The World Federation of Societies of Anaesthesiologists have developed guidance for perioperative personnel involved in airway management:

<https://www.wfsahq.org/resources/coronavirus>

Whenever practicable, decrease case duration, limit aerosolization (such as the release of pneumoperitoneum during laparoscopy), and when possible use viral filters and appropriate circuit cleaning measures for all patients with suspected or known COVID-19 infection requiring mechanical ventilation (11)(29). Each center should prepare its own airway management protocol with available resources in mind.

If single-use plastic anaesthesia or surgical equipment (endotracheal tubes, ventilator circuit tubing, plastic suction tubing, electrocautery handpieces) must be reused, ensure that disinfection aiming for “high-level disinfection” or “sterility” is employed(30)(27)(13). This includes immersion in appropriate concentration glutaraldehyde, phenol, or hydrogen peroxide solution for the

recommended duration(30). Surfaces in the OR should be thoroughly cleaned between cases including pulse oximeter probes, thermometers, blood pressure cuffs and other reusable materials; SARS-CoV-19, the virus causing COVID-19, is rapidly killed on surfaces with 70% alcohol solution or 0.5% Chlorine solution (9)(31). As part of minimizing contamination in OR, in addition to surface cleaning, using clear plastic sheets (to be changed in between patients) to cover the anaesthesia machine, the monitors as well as the patient's face, especially during aerosol producing airway maneuvers like intubation and extubation, is recommended.

Consider using a Checklist to ensure appropriate precautions are taken for operations with suspected or known COVID-19 infection (see Figure below)(13). Simulation has been helpful in establishing new routines in the operating theatre (14).

4. Prepare for shortages and conserve personal protective equipment (PPE) and consumables.

Many well-resourced countries are already experiencing shortages of PPE; this will further stress supply chains to Africa, as manufacturers will be working to fill backorders from countries that have been affected earlier in the pandemic timeline. Many facilities are familiar with severe resource shortages, so this experience may guide creative and innovative ways to conserve and extend necessary resources.

In resource-limited situations, extended use of N95 masks (continuous wearing while seeing multiple patients) is preferred to limited reuse of N95 masks (doffing and redonning between patients)(32). Furthermore, N95 mask life may be lengthened and surface contamination reduced by wearing a plastic face shield or a surgical mask over the N95 (CDC respirator guidance). Use of chlorine or alcohol solution to sanitize N95 masks is NOT recommended as it damages mask integrity. Heating N95 masks to 70°C (160°F) in a dry oven for 30 minutes seems a promising solution to disrupt viral particles and maintain mask integrity for reuse (33)(34). Further guidance from the United States Center for Disease Control (CDC) and Partners In Health (PIH) on reuse of

N95 masks or best practices when no respirators are available (such as wearing two surgical masks) are available(9)(17)(35)(36). Other innovative solutions are being proposed, as this example from Boston Children's Hospital demonstrates: https://www.youtube.com/watch?v=Es_iY5WJdml.

In routine clinical care of COVID-19 suspected or confirmed infections, surgical masks are acceptable PPE, except in the case of aerosol generating procedures (intubation, high flow nasal cannula, non-invasive ventilation, bronchoscopy, administration of nebulized medications, etc) (37). While N95 masks are superior to surgical masks in protecting HCWs against aerosolized viral particles, surgical masks still afford significant protection over no mask (36)(38)(39). It should be noted that aerosol-generating procedures that can be provided using other mechanisms should be avoided if at all possible (e.g. metered dose inhaler instead of nebulizer treatment).

Recognizing that many providers and facilities do not have disposable surgical attire, theatre garb in the form of cloth scrub hats or bonnets should be washed between each use if possible, and no less than daily. Theatre gowns and drapes should be washed and sterilized between each patient as is currently expected. If theatre gowns are repurposed for isolation units, they should be washed after each prolonged care routine. If surgical PPE is not impermeable, consider wearing rubber aprons under linen gowns, and always perform handwashing after doffing surgical PPE and before touching clean items or self. Of note, *the protection afforded by cloth masks for droplet and airborne particles is not well studied but may be significantly less than surgical masks and is not protective to the same extent as N95 respirators; it should be used as a last option only*(36)(9)(40)(41)(42)(43)(44).

5. Plan for the repurposing operating theatres to support critical care whilst not precluding the ability to provide lifesaving operative care

Surgical services are already underfunded and poorly prioritized in many health systems, so the commandeering of operating theatres for use as ICU, which has been proposed in many high-resource settings, must be done with extreme caution. Emergency surgery will still be necessary for obstetrics and to save life and limb, and these capacities should not be compromised by taking up

all available operating theatre space and ventilators with COVID+ patients. As the average reported time spent on mechanical ventilation has been up to 13 days(6)(45), critical resources and space will be occupied for many weeks and will be difficult to reclaim once repurposed.

6. Repurpose staff for managing COVID-19 cases

Oftentimes when health care workers fall ill or capacity is exceeded, other healthcare professionals will be asked to provide clinical services outside their normal scope of practice. Guidance and training should be provided to make best use of the technical and clinical skills of all perioperative personnel while protecting them from exposure. As screening and treatment guidance are in flux, these specific are beyond the scope of this paper, but guidance is available on an ongoing bases from WHO: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/patient-management>. Hospitals, professional societies, and ministries of health could also provide physician and nursing staff with basic ICU and ventilator management refresher education to improve their capacity to care for COVID-19 patients; SAGES has recently provided such a resource: <https://www.sages.org/basics-of-mechanical-ventilation-for-non-critical-care-mds/> and ICM guidance on critical care for COVID-19 patients: <https://icmanaesthesiacovid-19.org/clinical-guidance> (46). Up to date guidelines on COVID-19 management should be provided as knowledge and evidence around best management evolves (45)(47)(48)(49)(50)(51)(15)(52). Partners In Health have provided an excellent guide: https://www.pih.org/sites/default/files/2020-03/PIH_Guide_COVID_Part_II_Clinical_Management_3_21.pdf. A repository of the latest COVID-related research can be found at WHO: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov>.

7. Maintain and support staff wellness

It is important to recognize that doctors, nurses, cleaners, and other hospital support staff have significant fears and concerns that must be acknowledged and managed. The fears of transmitting to family or becoming infected oneself, the increase in work hours, and the need for childcare coverage are real. Providers may also be understandably nervous about providing care outside of

their normal scope of practice or working beyond their area of competence. Leadership can help manage these by providing information in a transparent way, expressing gratitude for the commitment to patients and colleagues, and reassurances that the system will help protect them and support them and their family. This is a time for visible leadership to listen to staff as they have ideas and concerns.

8. As noted in settings throughout the world, prepare for a rapidly evolving situation.

Severity of the situation and the availability of resources may change on a daily basis. Thus, communication is critical, and *an effective communication plan* both within and between facilities and health system planners, as well as between providers across the health system and even between countries, is essential and should be *established immediately*. The preparation of healthcare facilities at large for the safe triage, testing and management of patients with confirmed or suspected COVID-19, and managing surge conditions, is outside the scope of this document, but multiple guidelines are available to assist in decision making (9)(31). A useful tool for health system organization is the Incident Command System (ICS), a standardized hierarchical structure that enables a cooperative response by government and agencies to organize and coordinate activities; an online ICS training is available at no charge: <https://emilms.fema.gov/IS0700b/curriculum/1.html>.

9. Ethical considerations in resource management are vital

Shortages of healthcare resources including PPE, ventilators, hospital beds and medications for ill patients are to be expected in many nations worldwide, with worse shortages likely to occur in low-income countries with less purchasing power over supply chains of medical resources, and less excess capacity of healthcare systems at baseline. In many places the number of ventilators available for persons requiring ventilatory support will be inadequate; in some settings it is common to reallocate resources from terminal patients or patients with brain death or very low likelihood of recovery (e.g. severe TBI) to those with higher likelihood of recovery. In some contexts, family or community members of patients have in the past provided manually bag-ventilation of patients requiring respiratory support when ventilators are not available. However, given the risk of disease

spread during the COVID-19 pandemic, this is an unacceptable strategy when isolation units and PPE are in short supply. In settings where resources are severely limited and must be rationed, consider creating a committee or utilizing standardized risk assessments to determine allocation decisions in advance. This avoids placing the burden of decision making on the frontline health care workers, as these decisions should not be made ad hoc by the bedside clinician but through careful deliberations by the institution(9). Each country should consider its cultural and medicolegal context to determine the most appropriate allocation and potential protocols for rationing medical resources and care in advance. There are multiple resources for guiding the complex decision making in resource allocation and rationing in pandemic situations (53)(54)(55)(56)(57)(58). A recent ethical framework from the New England Journal of Medicine made the following priority recommendations(59)(60), amongst others: 1. As a priority for limited resources, aim to both save the most lives and most years of life, giving priority to maximizing the number of patients that survive treatment with reasonable life expectancy and maximizing improvements in length of life as a subordinate aim (maximizing benefit); 2. Critical testing, PPE, ICU beds, therapeutics, and vaccines should go first to front line health care workers and others who keep critical infrastructure functioning; these workers should be given priority not because they are more worthy but due to their instrumental value in the pandemic response and difficulty of replacing (instrumental value); and 3. For patients with similar prognoses, avoid first-come first serve approaches and use random allocation such as a lottery (equality). The Hastings Center has provided a freely available online resource that is helpful to guide an ethics process:

<https://www.thehastingscenter.org/ethicalframeworkcovid19/>.

The COVID-19 pandemic will be a tremendous challenge for health systems and providers in Africa. Much will be asked of us all in the coming weeks and months, and we may well find ourselves stretched and beyond our comfort zones. Our duty to our patients, our communities, and our families must be paramount. We will be remembered for our actions, and how we comported ourselves in the midst of this pandemic. Most importantly, our most valuable assets that we have to share are both free and priceless: our compassion, our empathy, and our words of comfort.

References:

1. Gilbert M, Pullano G, Pinotti F, Valdano E, Poletto C, Boëlle P-Y, et al. Preparedness and vulnerability of African countries against importations of COVID-19: a modelling study. *The Lancet*. 2020 Mar 14;395(10227):871–7.
2. Nkengasong JN, Mankoula W. Looming threat of COVID-19 infection in Africa: act collectively, and fast. *The Lancet*. 2020 Mar 14;395(10227):841–2.
3. Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. *Acta Bio-Medica Atenei Parm*. 2020 Mar 19;91(1):157–60.
4. SITREP_COVID-19_WHOAFRO_20200304-eng.pdf [Internet]. [cited 2020 Mar 20]. Available from: https://apps.who.int/iris/bitstream/handle/10665/331330/SITREP_COVID-19_WHOAFRO_20200304-eng.pdf
5. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis*. 2020 Feb 19;
6. Arentz M, Yim E, Klaff L, Lokhandwala S, Riedo FX, Chong M, et al. Characteristics and Outcomes of 21 Critically Ill Patients With COVID-19 in Washington State. *JAMA*. 2020 Mar 19;
7. Spinelli A, Pellino G. COVID-19 pandemic: perspectives on an unfolding crisis. *BJS Br J Surg* [Internet]. [cited 2020 Mar 24];n/a(n/a). Available from: <http://bjssjournals.onlinelibrary.wiley.com/doi/abs/10.1002/bjs.11627>
8. Brindle M, Gawande A. Managing COVID-19 in Surgical Systems. *Ann Surg Ahead Publ* <https://journals.lww.com/annalsofsurgery/Documents/Managing20COVID20in20Surgical20Systems20v2.pdf>. 2020;3.
9. COVID-19 Clinical Response | Partners In Health [Internet]. [cited 2020 Mar 21]. Available from: <https://www.pih.org/covid-response>
10. Iacobucci G. Covid-19: all non-urgent elective surgery is suspended for at least three months in England. *BMJ*. 2020 Mar 18;368:m1106.
11. Wen X, Li Y. Anesthesia Procedure of Emergency Operation for Patients with Suspected or Confirmed COVID-19. *Surg Infect*. 2020 Feb 25;
12. Seto WH, Conly JM, Pessoa-Silva CL, Malik M, Eremin S. Infection prevention and control measures for acute respiratory infections in healthcare settings: an update. *EMHJ - East Mediterr Health J* 19 Supp1 S39 - S47 2013 [Internet]. 2013 [cited 2020 Mar 21]; Available from: <https://apps.who.int/iris/handle/10665/118445>
13. Ti LK, Ang LS, Foong TW, Ng BSW. What we do when a COVID-19 patient needs an operation: operating room preparation and guidance. *Can J Anesth Can Anesth* [Internet]. 2020 Mar 6 [cited 2020 Mar 20]; Available from: <https://doi.org/10.1007/s12630-020-01617-4>

14. Wong J, Goh QY, Tan Z, Lie SA, Tay YC, Ng SY, et al. Preparing for a COVID-19 pandemic: a review of operating room outbreak response measures in a large tertiary hospital in Singapore. *Can J Anesth* [Internet]. 2020 Mar 11 [cited 2020 Mar 21]; Available from: <https://doi.org/10.1007/s12630-020-01620-9>
15. Alhazzani, Waleed. Surviving Sepsis Campaign: Guidelines on the Management of Critically Ill Adults with Coronavirus Disease 2019 (COVID-19). *Crit Care Med*. Ahead of pub; available at: <https://www.sccm.org/SurvivingSepsisCampaign/Guidelines/COVID-19>.
16. Braswell ML, Spruce L. Implementing AORN Recommended Practices for Surgical Attire. *AORN J*. 2012 Jan 1;95(1):122–40.
17. Personal protective equipment: Our process if COVID-19 is suspected | The Loop [Internet]. [cited 2020 Mar 21]. Available from: <https://medcom.uiowa.edu/theloop/news/personal-protective-equipment-our-process-if-covid-19-is-suspected>
18. Croke L. Guideline for surgical attire. *AORN J*. 2019;109(6):P8–10.
19. Hon C-Y, Gamage B, Bryce EA, LoChang J, Yassi A, Maultsaid D, et al. Personal protective equipment in health care: Can online infection control courses transfer knowledge and improve proper selection and use? *Am J Infect Control*. 2008 Dec 1;36(10):e33–7.
20. Lim SM, Cha WC, Chae MK, Jo IJ. Contamination during doffing of personal protective equipment by healthcare providers. *Clin Exp Emerg Med*. 2015 Sep 30;2(3):162–7.
21. Chughtai AA, Chen X, Macintyre CR. Risk of self-contamination during doffing of personal protective equipment. *Am J Infect Control*. 2018 Dec 1;46(12):1329–34.
22. Otter JA, Donskey C, Yezli S, Douthwaite S, Goldenberg SD, Weber DJ. Transmission of SARS and MERS coronaviruses and influenza virus in healthcare settings: the possible role of dry surface contamination. *J Hosp Infect*. 2016 Mar 1;92(3):235–50.
23. CDC PPE Donning and Doffing Sequence [Internet]. [cited 2020 Mar 21]. Available from: <https://www.cdc.gov/hai/pdfs/ppe/ppe-sequence.pdf>
24. Poston JT, Patel BK, Davis AM. Management of Critically Ill Adults With COVID-19. *JAMA* [Internet]. 2020 Mar 26 [cited 2020 Mar 26]; Available from: <http://jamanetwork.com/journals/jama/fullarticle/2763879>
25. Ng, Kangqi; Poon, Beng Hoong. COVID-19 and the Risk to Health Care Workers: A Case Report. *Ann Intern Med* [Internet]. 2020 Mar 16 [cited 2020 Mar 26]; Available from: <https://annals.org/aim/fullarticle/2763329/covid-19-risk-health-care-workers-case-report>
26. Chen C-C, Willeke K. Aerosol penetration through surgical masks. *Am J Infect Control*. 1992 Aug 1;20(4):177–84.
27. Rowley E, Dingwall R. The use of single-use devices in anaesthesia: balancing the risks to patient safety*. *Anaesthesia*. 2007;62(6):569–74.

28. Milton DK, Fabian MP, Cowling BJ, Grantham ML, McDevitt JJ. Influenza Virus Aerosols in Human Exhaled Breath: Particle Size, Culturability, and Effect of Surgical Masks. *PLoS Pathog* [Internet]. 2013 Mar 7 [cited 2020 Mar 20];9(3). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3591312/>
29. #. FAQ on Anesthesia Machine Use, Protection, and Decontamination During the COVID-19 Pandemic [Internet]. Anesthesia Patient Safety Foundation. [cited 2020 Mar 20]. Available from: <https://www.apsf.org/faq-on-anesthesia-machine-use-protection-and-decontamination-during-the-covid-19-pandemic/>
30. Rutala WA, Weber DJ. Disinfection, sterilization, and antisepsis: An overview. *Am J Infect Control*. 2019;47S:A3–9.
31. WHO. Water, sanitation, hygiene and waste management for the COVID-19 virus [Internet]. 2020 [cited 2020 Mar 21]. Available from: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/infection-prevention-and-control>.
32. Fisher EM, Shaffer RE. Considerations for Recommending Extended Use and Limited Reuse of Filtering Facepiece Respirators in Health Care Settings. *J Occup Environ Hyg*. 2014 Aug 3;11(8):D115–28.
33. Cui Y. Can Facial Masks be disinfected for re-use? Personal Communication: yicui@stanford.edu. Department of Materials Science and Engineering, Stanford University. McCullough Building, Room 343 476 Lomita Mall Stanford, CA 94305 USA; 2020.
34. Information and FAQs on Performance, Protection, and Sterilization of Masks Against COVID-19 [Internet]. University of Tennessee Research Foundation. 2020 [cited 2020 Mar 26]. Available from: <https://utrf.tennessee.edu/information-faqs-performance-protection-sterilization-of-masks-against-covid-19/>
35. WHO. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care [Internet]. [cited 2020 Mar 21]. Available from: <https://apps.who.int/iris/discover?query=Infection+prevention+and+control+of+epidemic+and+pandemic-prone+acute+respiratory+infections+in+health+care>
36. CDC. Strategies for Optimizing the Supply of N95 Respirators [Internet]. Centers for Disease Control and Prevention. 2020 [cited 2020 Mar 21]. Available from: <https://www.cdc.gov/coronavirus/2019-ncov/hcp/respirators-strategy/index.html>
37. Smith JD, MacDougall CC, Johnstone J, Copes RA, Schwartz B, Garber GE. Effectiveness of N95 respirators versus surgical masks in protecting health care workers from acute respiratory infection: a systematic review and meta-analysis. *CMAJ*. 2016 May 17;188(8):567–74.
38. Makison Booth C, Clayton M, Crook B, Gawn JM. Effectiveness of surgical masks against influenza bioaerosols. *J Hosp Infect*. 2013 May 1;84(1):22–6.
39. CDC. Coronavirus Disease 2019 (COVID-19) [Internet]. Centers for Disease Control and Prevention. 2020 [cited 2020 Mar 23]. Available from: <https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/face-masks.html>

40. MacIntyre CR, Seale H, Dung TC, Hien NT, Nga PT, Chughtai AA, et al. A cluster randomised trial of cloth masks compared with medical masks in healthcare workers. *BMJ Open*. 2015 Apr 1;5(4):e006577.
41. Rengasamy S, Eimer B, Shaffer RE. Simple Respiratory Protection—Evaluation of the Filtration Performance of Cloth Masks and Common Fabric Materials Against 20–1000 nm Size Particles. *Ann Occup Hyg*. 2010 Oct 1;54(7):789–98.
42. Davies A, Thompson K-A, Giri K, Kafatos G, Walker J, Bennett A. Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic? *Disaster Med Public Health Prep*. 2013 Aug;7(4):413–8.
43. Dato VM, Hostler D, Hahn ME. Simple Respiratory Mask. *Emerg Infect Dis*. 2006 Jun;12(6):1033–4.
44. van der Sande M, Teunis P, Sabel R. Professional and Home-Made Face Masks Reduce Exposure to Respiratory Infections among the General Population. *PLoS ONE* [Internet]. 2008 Jul 9 [cited 2020 Mar 22];3(7). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2440799/>
45. Wujtewicz M, Dylczyk-Sommer A, Aszkiełowicz A, Zdanowski S, Piwowarczyk S, Owczuk R. COVID-19 - what should anaesthesiologists and intensivists know about it? *Anaesthesiol Intensive Ther*. 2020 Mar 20;
46. Clinical guidance [Internet]. ICM Anaesthesia COVID-19. [cited 2020 Mar 24]. Available from: <https://icmanaesthesiacovid-19.org/clinical-guidance>
47. Baden LR, Rubin EJ. Covid-19 — The Search for Effective Therapy. *N Engl J Med*. 2020 Mar 18;0(0):null.
48. Ng Y, Li Z, Chua YX, Chaw WL, Zhao Z, Er B, et al. Evaluation of the Effectiveness of Surveillance and Containment Measures for the First 100 Patients with COVID-19 in Singapore - January 2-February 29, 2020. *MMWR Morb Mortal Wkly Rep*. 2020 Mar 20;69(11):307–11.
49. Tolksdorf K, Buda S, Schuler E, Wieler LH, Haas W. Influenza-associated pneumonia as reference to assess seriousness of coronavirus disease (COVID-19). *Euro Surveill Bull Eur Sur Mal Transm Eur Commun Dis Bull*. 2020 Mar 19;
50. Sun Q, Qiu H, Huang M, Yang Y. Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province. *Ann Intensive Care*. 2020 Mar 18;10(1):33.
51. Murthy S, Gomersall CD, Fowler RA. Care for Critically Ill Patients With COVID-19. *JAMA* [Internet]. 2020 Mar 11 [cited 2020 Mar 20]; Available from: <http://jamanetwork.com/journals/jama/fullarticle/2762996>
52. Maxwell DN, Perl TM, Cutrell JB. “The Art of War” in the Era of Coronavirus Disease 2019 (COVID-19). *Clin Infect Dis* [Internet]. [cited 2020 Mar 21]; Available from: <http://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa229/5800048>

53. Powell T, Christ KC, Birkhead GS. Allocation of Ventilators in a Public Health Disaster. *Disaster Med Public Health Prep.* 2008 Mar;2(1):20–6.
54. Fink SL. Worst case: rethinking tertiary triage protocols in pandemics and other health emergencies. *Crit Care.* 2010 Jan 21;14(1):103.
55. Patrone D, Resnik D. Pandemic Ventilator Rationing and Appeals Processes. *Health Care Anal.* 2011 Jun 1;19(2):165–79.
56. Vawter DE, Garrett JE, Prehn AW, Gervais KG. Health Care Workers' Willingness to Work in a Pandemic. *Am J Bioeth.* 2008 Sep 23;8(8):21–3.
57. Lin JY, Anderson-Shaw L. Rationing of Resources: Ethical Issues in Disasters and Epidemic Situations. *Prehospital Disaster Med.* 2009 Jun;24(3):215–21.
58. Howes D, Tsai E. Ventilator Allocation In A Pandemic: Discussion And A Model For Rationing Restricted Resources. 2010 Dec 3 [cited 2020 Mar 20]; Available from: <http://www.webmedcentral.com/>
59. Vawter D, Garrett J, Gervais K, Prehn A, Debruin D, Tauer C, et al. For the good of us all: Ethically rationing health resources in Minnesota in a severe influenza pandemic. 2020 Mar 27;
60. Emanuel EJ, Persad G, Upshur R, Thome B, Parker M, Glickman A, et al. Fair Allocation of Scarce Medical Resources in the Time of Covid-19. *N Engl J Med.* 2020 Mar 23;

Figure: Perioperative Checklist for operations on confirmed or suspected patients with COVID-19

COVID-19 Patient & Health Care Worker Safety Checklist <small>*To be used in conjunction with WHO Surgical Safety Checklist</small>		
Before patient arrives in operating room	Once patient in operating room	After operation: Patient recovery
<p><u>To Nursing Team:</u> COVID or Infection Prevention team notified/activated? <input type="checkbox"/> Yes <input type="checkbox"/> No COVID Notification tags placed on door <input type="checkbox"/> Yes <input type="checkbox"/> N/A, COVID-specific OR All non-essential equipment & supplies removed from Operating Room <input type="checkbox"/> Yes <input type="checkbox"/> N/A, COVID-specific OR</p> <p>PPE and Mobile Phone on cart? <input type="checkbox"/> Yes <input type="checkbox"/> No Viricidal spray/wipes available on cart? <input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p><u>To Anesthesia Provider:</u> Drugs and intubation equipment assembled on cart? <input type="checkbox"/> Yes <input type="checkbox"/> No Is the pulse oximeter available and functioning? <input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>Planned postoperative isolation prepared: <input type="checkbox"/> Ward <input type="checkbox"/> ICU</p> <p><input type="checkbox"/> Scrub nurse brings cart with anticipated OR supplies and PPE into room, otherwise OR is cleared of other materials</p>	<p><u>To Anesthetist: Pre Intubation</u> <input type="checkbox"/> All non-essential personnel leave room <input type="checkbox"/> Anesthesia providers don PPE including N95 mask <input type="checkbox"/> Viral filter on anesthesia circuit</p> <p><u>To Nursing Team:</u> <input type="checkbox"/> External Runner designated to stay outside OR <input type="checkbox"/> If additional supplies needed, they are called for by phone and delivered to door of OR <input type="checkbox"/> Patient trolley wiped with bleach and/or alcohol</p> <p><u>To Surgeon:</u> <input type="checkbox"/> Minimize duration of surgery <input type="checkbox"/> Minimize aerosolization (If any insufflation used, venting should be slow and controlled, and ideally through tubing circuit with viral filter) <input type="checkbox"/> Only essential assistance - no trainees if possible</p> <p>Transport team activated at end of operation? <input type="checkbox"/> Yes <input type="checkbox"/> No</p>	<p>Specimen Handling: <input type="checkbox"/> All specimens double bagged <input type="checkbox"/> Porter wears gloves for transport</p> <p>To Anesthetist: <input type="checkbox"/> Patient extubated and recovers in operating room Final postoperative isolation: <input type="checkbox"/> Ward <input type="checkbox"/> ICU</p> <p><u>Removal of PPE/PAPR:</u> <input type="checkbox"/> In OR: Remove shoe cover, gowns, gloves <input type="checkbox"/> Outside OR: Remove N95/PAPR, goggles, cap <input type="checkbox"/> Personnel to shower after case</p> <p><u>Waste Management:</u> <input type="checkbox"/> All unused materials from OR double bagged in plastic bag <input type="checkbox"/> Waste bags sprayed with viricidal spray in anteroom <input type="checkbox"/> Transport wears gloves to deliver trash to waste receptacle or incinerator</p> <p><u>Operating Room disinfection:</u> <input type="checkbox"/> Clean all surfaces (floor, OR table, stools) with bleach <input type="checkbox"/> Clean PAPR with Virex (alternative??) <input type="checkbox"/> Clean goggles/face shield with alcohol</p>
<p>*Ref: Ti LK, Ang LS, Foong TW, Ng BSW. What we do when a COVID-19 patient needs an operation: operating room preparation and guidance. Can J Anesth Can Anesth [Internet]. 2020 Mar 6 COVID-19 Clinical Response Partners In Health [Internet]. [cited 2020 Mar 21]. Available from: https://www.pih.org/covid-response</p>		

Table: Recommendations for COVID-19 preparedness within the surgical and anaesthetic ecosystem in sub-Saharan Africa

1	Develop a clear plan for essential operations during pandemic	<ul style="list-style-type: none"> ○ Postpone truly elective operations to preserve PPE, staff and facility capacity ○ Adapting algorithms to categorize cases as elective, urgent or emergent, and enforce them ○ Trial nonoperative management of patient conditions when safe for patients ○ Keep COVID+ patients geographically separate from other surgical patients ○ Consider dedicating one operating room for COVID+ patient use only if case burden is high ○ Operating rooms used for COVID+ patients should be kept at neutral or negative pressure
2	Decrease exposure of health care staff	<ul style="list-style-type: none"> ○ Train staff on appropriate donning and doffing of PPE ○ Encourage simulation and using two providers for donning/doffing procedures Limit unnecessary patient and physician movement through the hospital, limit visitors ○ Avoid involving students and trainees in patient care of COVID+ patients when possible ○ Minimize the staff required in the hospital to preserve human resources ○ All staff including cleaners, laundry personnel and others should be provided with appropriate PPE to their job descriptions and trained to don and doff safely ○ Launder all contaminated linens with detergent regularly and disinfect all hard surface areas regularly with 0.5% chlorine or 70% alcohol solution
3	Prevent transmission of coronavirus to other patients and personnel	<ul style="list-style-type: none"> ○ Enforce frequent and proper handwashing practices. Medicated soap and alcohol-based hand rub should be available to all staff easily in the hospital ○ Alcohol-based hand rub can be locally manufactured easily and inexpensively ○ Develop care protocols and teams specifically for COVID response ○ Consider establishing a COVID+ only operating room to be cleared of all materials ○ Minimize aerosols during anesthesia provision: use regional anesthesia when possible, most senior provider should attempt intubation, only absolutely essential personnel in OR during intubation, recover patients in OR rather than PACU ○ Limit case duration, limit aerosolization during laparoscopy ○ Consider use of COVID checklist for suspected or known COVID patients undergoing surgery ○ If reprocessing single use plastic materials, achieve high-level disinfection or sterilization
4	Conserve PPE and consumables	<ul style="list-style-type: none"> ○ Develop a clear understanding of current stocks and supply chains ○ Airborne precautions (N95 or PAPR) only required during aerosolizing procedures (intubation, bronchoscopy, NIPPV, high flow nasal cannula oxygen, nebulized medication administration) ○ Use droplet & contact precautions (surgical mask, eye protection, gown, gloves) for other patient encounters with suspected or known COVID patient. ○ Extended use of N95 masks is preferred to reuse of the same mask ○ N95 mask contamination may be reduced by covering with plastic face shield or surgical mask ○ Do not decontaminate N95 respirators with chlorine or alcohol solution ○ If severe shortage, consider reprocessing N95 masks in 70°C oven for 30 minutes ○ Wash reusable PPE (cloth hats, gowns, etc) between each use Cloth masks should be used as a last option only and provide little protection against droplet or airborne particles
5	Plan to expand critical care	<ul style="list-style-type: none"> ○ Carefully consider if and how many ORs could be repurposed for critical care needs ○ Preserve hospital capacity to care for surgical and obstetric emergencies
6	Repurpose staff for managing COVID cases	<ul style="list-style-type: none"> ○ Prepare providers to work outside their usual scope of practice ○ Provide refresher trainings on ventilator management, critical care, and COVID-specific care guidelines to providers who may be asked to work in different areas
7	Maintain and support staff wellness	<ul style="list-style-type: none"> ○ Provide material and psychological resources to staff during this time of crisis ○ Consider how needs such as HCW home isolation, child care, meal preparation, or general stress management can be supported by hospital leadership
8	Prepare for a rapidly evolving situation	<ul style="list-style-type: none"> ○ Establish communication plan within and between facilities and providers ○ Prepare the facility for surge of patients with suspected or known COVID-19 based on available guidance
9	Plan for ethical considerations in resource management	<ul style="list-style-type: none"> ○ Develop a plan in advance for managing resource shortages and determining scarce resource allocation ○ Frontline healthcare workers should not have to make resource allocation decisions alone ○ Provide compassion, empathy and respect for patients, family members, and healthcare workers in this time of crisis