THE STATE OF ANESTHESIA PRACTICE IN SUB-SAHARAN AFRICA: STATISTICS, CASE STUDIES, AND WAYS FORWARD

by

VINCENT CHOO

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ABSTRACT

The State of Anesthesia Practice in Sub-Saharan Africa: Statistics, Case Studies, and Ways Forward

VINCENT CHOO
The University of Texas Southwestern Medical Center, 2020
Supervising Professor: Angela Mihalic, M.D.

Background: There is substantial need for additional anesthesia resources in Sub-Saharan Africa. In this region of the world, maternal and surgical mortality are high. Non-coincidentally, the number of anesthesiologists and anesthesia providers is low and provision of medications and other basic supplies is lacking. This thesis aims to describe anesthesia practice in Sub-Saharan Africa using statistics and case studies, present current initiatives already in place to improve access to care, and suggest other strategies that may improve anesthesia capacity in the future.

Objective: Non-adherence to minimum guidelines from the World Federation of Societies of Anaesthesiologists (WFSA) for anesthesia practice in the areas of staffing and physical resources is associated with poor anesthesia and surgical outcomes, which could be improved by improving training programs and increasing available physical resources.

Methods: A Pubmed literature search was performed using key words. Relevant articles from these searches were retrieved and references from these articles were also examined. Websites for organizations mentioned in the articles were queried. Websites containing factual information about individual Sub-Saharan African countries were consulted. The information found was grouped by themes and presented.

Results: The numbers of anesthesiology providers in Sub-Saharan Africa are insufficient to provide safe anesthesia care. A lack of medications and supplies and inadequate technology, including monitoring equipment, contribute to the problem. The situation in Ghana, Mozambique, Liberia, and Rwanda helps to illustrate this problem. Initiatives such as the founding of the World Federation of Societies of Anaesthesiologists and Lifebox, as well as formalizing task-sharing, have attempted to improve the situation. Continuing to ensure that equipment adapted to the reality of the practice environment in the region and careful planning and coordinating of future humanitarian projects can help improve anesthesia care provided in the region.

Conclusion: The current state of anesthesia in Sub-Saharan Africa is insufficient to meet population needs. The causes are multi-factorial and include issues providing adequate human and material resources. Establishing strong, coordinated humanitarian efforts on the ground is critical to addressing the problem. Reorganizing manpower to best utilize precious human resources is another way forward. Providing appropriate resources in the form of equipment and medications, as well as encouraging local research, can help provide innovative solutions for the region.
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Chapter 1: Introduction.

The inspiration for this thesis comes from the year I spent abroad as part of UT Southwestern’s International Medical Exchange Program, which provides the opportunity for medical students to participate in clinical rotations in Paris, France for 6 months and in two other locations of the student’s choosing in lesser developed countries. I spent 3 months rotating at the Hôpital Cochin in Paris, France in Anesthesiology, as well as 3 months shared between the Emergency Room at the Hôpital Cochin, as well as the ambulance-based Service mobile d’urgence et réanimation (SMUR) of the Hôtel-Dieu in Paris, France. I also spent 3 months in Anesthesiology at the Fundación Favoloro in Buenos Aires, Argentina, as well as three months at the Hospital Santa-Isabel-de-Hungría in Guaymallén, Mendoza, Argentina.

The Hôpital Cochin is located in 14th arrondissement (borough) of Paris and is part of the public network of the Assistance Publique—Hôpitaux de Paris. Annually, there are approximately 35,000 surgeries performed across its 3 sites, of which more than 14,000 are performed on an ambulatory basis. There are 29 operating rooms total in the institution. (1) I rotated through the anesthesiology department’s orthopedic sector under the direction of Dr. Freedom Antus and Dr. Alan Benoliel and the department’s gastrointestinal/abdominal surgery sector under the direction of Dr. Charlotte Godberge and Dr. Hussam Foufa.

The Fundación Favoloro—Hospital Universitario is a private, not-for-profit hospital founded in 1992 by Doctor René Favoloro, an Argentinian physician known as the “Father of the Cardiac Bypass.” (2) Located in Buenos Aires, Argentina, near the National Congress, the hospital has 242 beds and 7 operating rooms. I spent 3 months there under the direction of Dr. Luis Valdivieso. To date, the hospital has performed 2,000 organ transplants (including heart, kidney, liver, and lung) and annually performs about 7,000 surgeries. Associated with the
Fundación are residencies in various fields, including General Surgery, Cardiovascular Surgery, and Critical Care. Although, no anesthesia residency is offered, external rotating residents can choose to come to the Fundación for periods of time to benefit from the hospital’s expertise, particularly from the relatively large number of cardiac cases that are performed. (3)

During my time in Paris and Argentina, I was exposed to Anesthesia in relatively well-resourced hospitals, with standards quite similar to those of the United States. However, from didactic exposure to Global Health and orientation materials provided through the UT Southwestern Office of Global Health, I know that the field of Global Health frequently works in some of the poorest countries in the world where healthcare workers are frequently confronted with insufficient resources. Many of these countries are found in Sub-Saharan Africa, where there is some of the greatest need and this was borne out by that fact that most of the Global Health literature I found when trying to research information for this thesis originated in work done in that region of the world. Thus, to round out my Global Health experience, I decided I would focus my thesis on anesthesia in this region of Africa: to learn more about the state of anesthesia in sub-Saharan Africa, what some of the major problems that exist, what has been done to date, and what types of planning and interventions might be most effective in the future.

To find the material that would support this thesis, a Pubmed literature search was performed using key words. In the initial search, the key words used were: “Africa,” “low resource countries,” “anesthesia,” and “research.” Relevant articles from these searches were retrieved and references from these articles that either supported a statement that could be expanded upon in this thesis or that had a title that appeared relevant to the themes of this paper, were also examined. Websites for organizations mentioned in the articles (including that of the World Federation of Societies of Anaesthesiologists and the links to individual countries’
anesthesia society websites) were also queried. Websites, including those of the World Health Organization and the United States State Department, containing factual information about individual Sub-Saharan African countries, were consulted. The information found was grouped by themes and presented. To find a unifying concluding example, another Pubmed search was run using the terms “Mark Newton” AND “East Africa” and three articles that described specific interventions led by Dr. Newton were retrieved and examined.

There is a great anesthesia need that is not being met in the region of Sub-Saharan Africa, due to a multitude of factors. Non-adherence to minimum guidelines from the World Federation of Societies of Anaesthesiologists (WFSA) for anesthesia practice in the areas of staffing and physical resources is associated with poor anesthesia and surgical outcomes, which could be improved by improving training programs and increasing available physical resources.

Chapter 2: International Standards of Practice.

Introduction. Some of the major organizations involved with anesthesia global health work include the World Health Organization (WHO) and the World Federation of Societies of Anaesthesiologists (WFSA). The WHO is the United Nations organization dedicated to health and well-being, with an overarching goal to promote the highest levels of health among nations across the globe, particularly among the vulnerable. (4) The WFSA is made of 136 individual societies of anesthesia across 150 countries, which include numerous countries in sub-Saharan Africa. (5) The mission of the WFSA includes advocating for safe anesthesia and perioperative medicine worldwide. (6) Perhaps the best way to understand the state of anesthesia in sub-Saharan Africa is to assess various benchmarks in terms of what is considered to be safe practice.
When considering anesthesia, some of the main measurements available include the number of providers available for a given region’s population, as well as availability of medications, and availability of equipment such as anesthesia machines, and monitors.

**Ratio of Providers to Population.** The *Lancet* Commission on Global Surgery suggests that, based on observed maternal mortality rates and the inflection point observed of the mortality curve, about 20 surgeons, anesthetists, and obstetricians are required per 100,000 population to provide optimal outcomes. (7) This estimate does not break down the specific specialty of each individual physician, so the WFSA extrapolated that this would equate to about 5-10 anesthesiologists per 100,000, based on the assumption that every surgeon or obstetrician would need at least one anesthesiologist or anesthesiology technician present at all times to support their work. (8) More recent data using published maternal mortality data versus ratios of anesthesia providers to population and drawing a best fit curve generally confirms this estimate, with the curve inflection point, where death rates begin to increase rapidly, occurring at about 4 anesthesia providers per 100,000 population. (9)

The WFSA, in 2015 and 2016, attempted to quantify the number of physician and non-physician providers that were working in each country in the world and extrapolate the anesthesia provider to population ratio by using the known population of each country. In Africa, they reported data from 37 countries. Only one, South Africa, had 5 or more providers per 100,000 people, at 16.18. (8) Only 5 countries out of the 37 African countries surpassed 1 provider to 100,000 people. (8) Even when non-physician anesthesia providers were considered, with varying levels of formal training and credentialing, 34 countries of the African continent still did not meet the 5 provider per 100,000 people threshold. Notably, out of the 153 countries worldwide for which data is available, 70 did not meet the threshold, which means half of those
countries are found in Africa, highlighting the magnitude of the problem in just this one region. As a point of comparison, the United States has 20.82 anesthesia providers per 100,000 people, France has 15.06 per 100,000 and Argentina has 10.96 per 100,000. (8)

One thing to consider when interpreting these ratios is that they are averages over the entire country. Thus, they do not take into account the distribution of anesthesia providers within a country. In reality, anesthesia providers, particularly physician anesthesiologists, tend to concentrate in major metropolitan areas. For example, in a survey done in five East African countries, including Uganda, Kenya, Tanzania, and Burundi, researchers found that providers were mostly located in the cities of Kampala, Nairobi, Dar es Salaam, Kigali, and Bujumbura. (10) An interesting finding, though, is that non-physician anesthesia providers were more evenly spread throughout the country. (10) This may be due, in part, to the fact that the majority of anesthesia sub-specialty training occurs in urban areas. This is not a phenomenon unique to Sub-Saharan Africa, however, as even in countries such as the United States, rural areas have difficulty attracting sufficient numbers of providers to meet community need. (11) The WFSA, in putting together their International Standards for a Safe Practice of Anesthesia, a document which was last revised in 2010, was careful to not stipulate the level of training of anesthesia personnel when they made recommendations for the number of providers, i.e., they did not state that the provider had to be a physician anesthesiologist to count towards reaching the 5 provider per 100,000 goal. Instead, they specified that an anesthetic officer, who may have had only on-the-job training, could be adequate in certain circumstances. (12) This recognizes the scarcity of formally trained anesthesia providers in resource-poor areas and adapts anesthesia standards to the reality of the situation in many of these areas.
**Essential Medications.** Every 2 years, the WHO compiles a model list of the medications they consider essential, with the last update occurring in June 2019. (9) The core list includes minimum medications for a basic hospital set-up and are selected on the basis of their efficacy, safety, and cost-effectiveness, as well as relevance to public health. For anesthesia, these medications are: halothane, isoflurane, nitrous oxide, oxygen, ketamine, propofol, bupivacaine, lidocaine, lidocaine plus epinephrine, atropine, midazolam, and morphine. For pain control, these medications are: acetylsalicylic acid, ibuprofen, paracetamol, codeine, fentanyl, and morphine. (13) The WFSA’s International Standards propose a similar, but modified list of core anesthetic drugs, which include: ketamine, lidocaine, midazolam, pethidine, morphine, epinephrine, atropine, and, given the presence of a vaporizer, any appropriate inhaled anesthetic agent. (14)

In reality, medication supply and distribution is hampered by government policies, hoarding and stockpiling issues, as well as smuggling and corruption. (11) In one study in Ethiopia, stock outs of medications were commonly noted, ranging from 1.4 days for acetaminophen to 144 days for oral rehydration salts over the year of observation. Also observed was the frequent undercounting of actual stock compared to the “official” count and a lack of organized documentation to keep track of medications. (15) Adding to the difficulty of getting medications to recipients, patients are often required to procure their own medications and bring them to the hospital before medical services are rendered. (11) In a 2019 study in Malawi of 50 essential medications, 50 percent were available in public facilities and 70 percent were available in retail pharmacies. In regards to multiples of the international reference price, wholesalers were selling at a 1.11 ratio and retail pharmacies were selling at a 2.7 ratio, which, although low by international standards, is still the equivalent of 10 days of work for a course of ceftriaxone, 6
days of work for diazepam, and 7 days of work for magnesium sulfate from private pharmacies, calculated from the lowest wage for unskilled labor. (16)

**Equipment.** The WFSA’s International Standards describe both non-disposable and disposable minimum equipment for safe anesthesia care, listed in Table 2.

Table 1. Basic anesthesia equipment (12)

<table>
<thead>
<tr>
<th>Non-Disposable</th>
<th>Disposable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-inflating breathing bags with masks, adult and pediatric</td>
<td>Gloves</td>
</tr>
<tr>
<td>Foot-powered suction</td>
<td>Equipment for intravenous infusions</td>
</tr>
<tr>
<td>Sphygmomanometers (to measure blood pressure)</td>
<td>Suction catheters</td>
</tr>
<tr>
<td>Thermometers</td>
<td>Tracheal tubes</td>
</tr>
<tr>
<td>Pulse oximeters</td>
<td>Oral airways</td>
</tr>
<tr>
<td>Oxygen concentrators and tanks</td>
<td>Nasal Airways</td>
</tr>
<tr>
<td>Draw-over vaporizer with hoses</td>
<td></td>
</tr>
<tr>
<td>Laryngoscopes (to visualize the trachea for intubation)</td>
<td></td>
</tr>
<tr>
<td>Bougies (to facilitate the placement of airways)</td>
<td></td>
</tr>
</tbody>
</table>

In the aforementioned survey of 5 East African countries, researchers looking at the main teaching hospital of each country tried to assess which of 10 pieces of equipment were available among: electrocardiogram (EKG) machine, continuous pulse oximetry, continuous blood pressure monitor, capnograph (a monitor that can help determine whether a breathing tube is positioned correctly in the patient), thermometer, stethoscope, difficult airway cart, suction
machine, available recovery room, and available intensive care unit. No facility had all 10 and 3 providers out of the 85 interviewed said they had up to 8 of the 10. (10) Providers noted that monitors may be present in the hospital, but were broken, highlighting a need for qualified technicians and adequate support for equipment. Providers also noted that certain supplies that were required to run monitors were not available, such as electrodes to run the EKG machine or disposable removable pieces to use with the capnography, highlighting the need to consider more permanent and sanitizable equipment when procuring materials for the region. As a side note, only about half of the providers interviewed were aware that the WFSA International Standards for Safe Anesthesia exist, indicating a need for further training in the region of the principles of safe anesthesia care. (10)

A 2010 study attempted to quantify the numbers of operating rooms in Sub-Saharan Africa which were operating without pulse oximetry monitoring. Researchers divided the region into the four cardinal points to report their data. Of note, to appropriately interpret the study results, South Africa, which is not normally considered a low-resource country, is included in their reported southern region. The authors found that the proportion of operating rooms running without working pulse oximetry was 15.8% in the southern region, 58.4% in the western region, 67% in the central region, and 70.4% in the eastern region, which is the equivalent of millions of surgeries being performed with no objective measure of how a patient is oxygenating under anesthesia. In comparison, the percentage in high-income North America is less than 0.1% and that number hovers around 18% globally. (17)
Chapter 3: Literature Review: State of Anesthesia Practice

State of anesthesia training. In 2019, a group of researchers attempted to survey all the ways a practitioner could train to practice anesthesia in Africa. The group’s research encompassed 51 countries in total. Twenty-nine countries had both physician and non-physician anesthesia training, 4 had only physician training, 10 had only non-physician training, and 8 countries had no anesthesia training at all. The median duration of physician anesthesia programs was 48 months, with a range from 36-72 months. The median duration of non-physician anesthesia programs was 24 months, with a range from 9 to 48 months. (18) Both of these data points are consistent with program lengths in the United States, where the basic anesthesiology residency program is 48 months long, while training to become a Certified Registered Nurse Anesthetist (CRNA) or Anesthesiology Assistant (AA) is generally 24 months.

There was, nevertheless, great heterogeneity in the types of training offered. The researchers counted 30 different ways of training, with each “way” involving a difference in either the entry qualification, duration of training, or the qualification obtained at the end of the program. The greatest variety was found in non-physician anesthesia training. Out of these programs, 60 percent required a nursing background for entry, 14 percent required either nursing or other clinical experience for entry, 12 percent specifically required non-nursing clinical experience, and 14 percent required no clinical experience at all. (10) Apart from nursing, acceptable clinical experiences included having experience as a clinical officer, in midwifery, or in pharmacy. (10) In actual practice, in the East African study of 5 countries, the actual number of years of formal and informal anesthesia training was quite variable. Nurses or clinical officers who were practicing in anesthesia might have the aforementioned 2 years of formal training. However, assistant medical officers might have only 6 months to one year of formal anesthesia training.
training. Furthermore, anesthesia assistants often were able to work in anesthesia with only informal, on-the-job training. (10)

Qualifications awarded at the end of non-physician anesthesia training included a diploma, license, or certificate in 60 percent of cases, a bachelor’s degree in 24 percent of cases, and a master’s degree in 10 percent of cases. (18) Curricula varied widely, with a variety of teaching methods and content. About one-third of personnel stated that there was an accrediting agency that set practice guidelines for their profession and one-third stated that there was some sort of exit examination designed to measure competency. One of the main difficulties in compiling the survey results was the inconsistency in terminology. For instance, a student graduating from a program with a “diploma” may have the same training and qualifications as another graduating from a program with a “license.” Furthermore, a “provider” in one hospital setting or country may have different roles and responsibilities from a “provider” in a different location. (18) In Kenya and Zambia, for example, most non-physician anesthesia providers are known as ‘clinical officers,’ while in Tanzania, they are known as ‘assistant medical officers.’ (19)

**State of anesthesia as a profession.** In many places in Africa, anesthesiology is not seen as a desirable specialty, with low pay compared to surgical specialties and low interest among medical students due, in part, to lack of exposure during training. (20) Also, the number of non-physician anesthesia practitioners often outnumbers that of physician anesthesiologists. Thus, both types of students are generally trained side-by-side, often with non-physician trainers, which impacts the student experience. (21) It has been reported that, as a way to cut costs, hospitals preferentially hire nurse anesthetists over physician anesthesiologists, thereby reducing prestige and job opportunities of the specialty for physician anesthesiologists. (22) In some
countries, resident physicians are required to practice in the public sector prior to entering specialist training programs and many decide to continue working after the required period is over, rather than to return to training. (23) Even the practice of anesthesia among non-physicians is not considered to be particularly prestigious, as these practitioners are seen as second-class professionals to their medically trained colleagues. (24)

Perhaps due to the lack of numbers of anesthesiologists in each country, as well as lack of interest on the part of the professionals involved, membership in each country’s professional anesthesiology associations is low. For instance, Mozambique’s Associação de Anesthesiologistas de Moçambique has 17 members for a population of 23 million people, and 50 anesthesiologists. (25, 26, 8) Kenya’s Kenya Society of Anaesthesiologists has 162 members for a population of more than 48 million, and about 152 practicing anesthesiologists. (27, 28, 8) Ethiopia’s Ethiopian Society of Anaesthesiologists has 24 members for a population of more than 102 million people, and 23 anesthesiologists. (29, 30, 8). That contrasts with the United States’ American Society of Anesthesiologists’ 32,235 members for a population of 322 million, and about 55,000 anesthesiologists. (31, 32, 8), France’s Société Française d’Anesthésie et de Réanimation’s 2,500 members for just under 65 million people and 7,800 anesthesiologists, (33, 34, 8) and Argentina’s Federación de Asociaciones de Anestesia, Analgesia y Reanimación, with 4,050 members for just under 44 million people, and 4010 practicing anesthesiologists. (35, 36, 8) If we consider that these professional organizations act as forums for the promulgation of best practices and professional networks, as well as support continuing education efforts, and push for population safety and professional guidelines, the lack of membership in the organizations signals a lack of a potential resource that can be used to improve the safety of anesthesia care. (37)
Maternal mortality and surgical data. Africa accounts for about 50 per cent of the 300,000 worldwide maternal pregnancy-related deaths, which equals a rate of 500 deaths per 100,000 live births, or 0.5 percent. (38) This compares to 18 deaths per 100,000 live births in the United States (39) and 41 deaths per 100,000 live births in Argentina. (40) In a survey of 11 hospitals in Liberia, out of 589 operations performed, almost half the cases were obstetric-gynecological cases. (41) In a survey of 21 Rwandan hospitals, out of over 45,000 surgeries performed, over 18,000 (40.4%) were considered emergencies, including emergency caesarian sections. In the same survey, hospitals reported that 50% of births were done via caesarian section, most of which were done as emergency cases. (42) A 2016 literature review found that, in low and middle-income countries, caesarian section was one of the most common surgeries performed, and that various anesthesia related complications, including failed tracheal intubation, bronchospasm, failure to monitor, drug adverse reactions, and cardiac arrest at induction often caused maternal mortality of about 1.2 per 1,000 live births, with anesthesia responsible for up to 13.6 percent of maternal deaths during caesarian section. (43, 44) Due to the link between maternal mortality and anesthesia and because intra-operative and post-operative mortality is difficult to track due to lack of records, maternal mortality data may be seen as a rough proxy for the quality of health care, including anesthesia, in some of the country case studies that follow.

In 2008, a group of researchers attempted to estimate the number of surgeries performed in groups of countries that they divided based on the amount each country spent on health care per year per person: less than US$100, between US$401 and US$1,000, and greater than US$1,000. Countries in the latter group had 35 times the major surgical volume than the former group when calculated on a per 100,000 population basis. This means that 30.2 percent of the world’s population in the middle and high expenditure countries had 73.6 percent of the global
major operations, while 34.8 percent of the world’s population in the low expenditure populations had 3.5 percent of the world’s major surgical operations. (45) It is worthwhile to note that, in compiling their statistics, the authors were unable to obtain surgical information on 37 out of the 46 African countries they attempted to survey. (45) We can surmise that the countries reporting data had the financial resources and capacity to report such data, meaning that even less procedures per given population may be occurring in the very poorest of countries because multiple countries that do not have resources to report likely also are experiencing difficulties with their surgical capacity. The numbers are low enough in resource poor-settings to mean that it is likely life-saving or medically necessary operations are not being done in Africa. This study also highlights the great difficulty in trying to measure anesthetic outcomes, when facilities simply do not have the resources to track or categorize such results.

**Chapter 4: Literature Review: Case Studies of 4 Sub-Saharan African Countries.**

The following literature review is composed of case studies of four Sub-Saharan African countries, Ghana, Mozambique, Liberia, and Rwanda, roughly following the same order previously described to assess each country’s anesthesia capacity in terms of human resources, medications, and equipment, as well as finishing with a brief primer of the state of anesthesia education in each country. To provide context for some of the data provided, comparison data for the United States is as follows (see Table 1): The United States has a total population of 329 million people. About 82.5% of the total population lives in an urban area, with the three largest areas being the New York area (18.8 million), the Los Angeles area (12.4 million), and the Chicago area (8.9 million). There are 2.59 physicians per 1,000 people and 2.9 hospital beds per 1,000 people. (46) The United States spends $9,403 per person annually on health care, which represents 17.1% of gross domestic product (GDP), although this is a larger share than other
high-income countries. Life expectancy is 76 years for males and 81 years for females. (32)

Maternal mortality is 18 per 100,000 live births. (39)

Table 2. Comparison of Selected Health Related Statistics between Selected Sub-Saharan African Countries and the United States (26, 32, 39, 42, 43, 44, 45, 50, 51, 54, 55, 56, 59, 60, 61)

<table>
<thead>
<tr>
<th>Country</th>
<th>Population/ % urban</th>
<th>Physicians Hosp. Beds per 1000 ppl</th>
<th>Hosp. Beds per 1000 ppl</th>
<th>Life Eptcy, M/F (yrs)</th>
<th>Health Exp. as % GDP</th>
<th>MMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>329 million/ 82.5%</td>
<td>2.59/2.9</td>
<td>17.1</td>
<td>76/81</td>
<td>18</td>
<td>20.82</td>
</tr>
<tr>
<td>Ghana</td>
<td>28 million/ 56%</td>
<td>0.18/0.9</td>
<td>3.6</td>
<td>62/64</td>
<td>320</td>
<td>0.40</td>
</tr>
<tr>
<td>Mozambique</td>
<td>27 million/ 36.5%</td>
<td>0.07/0.7</td>
<td>7</td>
<td>58/62</td>
<td>318</td>
<td>0.21</td>
</tr>
<tr>
<td>Liberia</td>
<td>5 million/ 52%</td>
<td>0.04/0.8</td>
<td>10</td>
<td>62/64</td>
<td>691</td>
<td>0</td>
</tr>
<tr>
<td>Rwanda</td>
<td>12 million/ 17%</td>
<td>0.13/N/A</td>
<td>7.5</td>
<td>66/70</td>
<td>275</td>
<td>0.34</td>
</tr>
</tbody>
</table>

MMR=Maternal Mortality Rate per 100,000 births

**Ghana.** Ghana is a country in West Africa, with a total population of about 28 million people.

About 56 per cent of the population lives in urban areas, with the three largest cities being Kumasi (3.2 million people), Accra, the capital city (2.5 million people), and Sekondi Takoradi (900,000 people). There are 0.18 physicians per 1000 people and 0.9 hospital beds per 1,000 people. (47) The country spends about $145 per person on health expenditures, which represents 3.6% of the country’s GDP. Life expectancy is 62 years for males and 64 years for females. (48) Maternal mortality is 320 deaths per 100,000 live births. (49)
The Ghana Anaesthetist Society, headquartered in Accra, has 50 members. (50) It was founded in 1996 and joined the WFSA in 2004. (51) Recent achievements of the Society include a 2015 set of workshops and classes organized with the Faculty of Anaesthesia of the Ghana College of Physicians and Surgeons, as well as a meeting of stakeholders to discuss anesthesia standards of practice, also in 2015. (50) There are 70 practicing anesthesiologists and 22 anesthesiology residents in the country, all of whom practice in urban centers (Kumasi, Accra, etc.). There are 565 nurse anesthetists who are similarly concentrated in urban areas. (22)

A prospective observational study specifically looking at anesthesiology was done in 2016 at the Konfo Anokye Teaching Hospital (KATH), Ghana’s second largest hospital with 1,200 beds, in Kumasi. Similar to practice settings in the United States, anesthesiologists practiced in pre-operative clinics and the operating room, as well as ran a 6 bed cardiac critical care unit. The anesthesia staff included 10 anesthesiologist attending physicians, 7 anesthesiologist resident physicians, 2 physician medical officers (first year medical residents), 61 nurse anesthetists, and 0 anesthesia technicians. Most WFSA-recommended drugs were available at KATH, with the exception of pancuronium, hyperbaric lidocaine, nitrous oxide, some IV antiarrhythmic drugs, and IV nitroglycerin. Not all medications were available at all times, however. (22)

In the same study at KATH, the central oxygen supply was not reliable and backup oxygen cylinders were generally empty, with no oxygen concentrators onsite. Electricity, however, was generally reliable, as outages were compensated for by a backup generator. Clean water was also consistently available. Basic laboratory tests (blood counts, blood gases, coagulation panels, glucose monitoring, metabolic panels) and radiologic exams (chest x-ray, computed tomography, transthoracic echocardiography) were available. Syringes, needles, and
topical disinfectant were also available, as was most basic WFSA equipment. However, capnographs, inspired/expired anesthetic gas monitors, and thermometers were not available. Difficult airway equipment was also not available and ventilators in the PACUs and CCUs was often broken. PACU equipment was often shared and some equipment was resterilized onsite, even if the equipment was not indicated for reuse by the manufacturer. Pulse oximeters donated by Lifebox, a program which will be discussed later in this thesis, were available onsite. (22)

In a 2010 study based on a WHO tool designed to assess surgical care, 17 health facilities in Ghana were surveyed, consisting of 14 district hospitals and 3 private, non-governmental, or mission based hospitals. (52) There were no physician anesthesiologists at any of the facilities. Ninety-four percent had access to running water and 53 percent had a blood bank. Overall, 86 percent of general supplies from a standardized list were available, as were 78 percent of a list of general intra-operative supplies. However, only 54 percent of anesthesia equipment and supplies were available. (52) It is estimated that about 76 percent of hospitals in Ghana have continuous access to electricity and 82 percent of hospitals have continuous access to oxygen. (53)

The accrediting organizations for postgraduate anesthesia education in Ghana are the Ghana College of Physician and Surgeons and the West African College of Surgeons. These two bodies prescribe the curriculum, based on the British educational system, which is used at both KATH and the Korle Bu Teaching Hospital in Accra. The initial level of training is at the “specialist” level and last 3 years, while the sub-specialized “consulting” level requires an additional 2 years of training. Nurse anesthetist training requires high school and nursing school diplomas plus 2 years of nursing experience for entry. The training program itself lasts for two years and is offered in 3 locations in Ghana. The program is taught by physicians and leads to a
Bachelor’s of Science degree. Upon passing an exit exam, the candidate is technically allowed independent practice, although this does not generally occur in reality. (22)

Upon review of data from KATH, the post-operative mortality rate is recorded as 299 per 46,000 cases over 5 years, or 1 per 154 cases, 2 of which occurred intra-operatively and the others occurring post-operatively. Relatively little information is recorded about the deaths, including time after surgery, so presumably not all deaths were necessarily related to anesthesia itself. More likely is that issues such as an unreliable oxygen supply and lack of ventilators contributed to the rate of mortality. (22)

In summary, in Ghana, it appears that state of anesthesia as a profession has made strides in recent years, with a relatively well organized anesthesia educational system, as well as a relatively active anesthesiologist professional association. It appears that both medications and supplies are also relatively available. Equipment availability, however, is a concern in Ghana, especially in terms of oxygen and ventilator availability, which could explain the country’s relatively high post-operative mortality rate.

**Mozambique.** Mozambique is a country in Southeastern Africa, with a total population of about 27 million people. About 36.5 per cent of the population lives in urban areas, with the three largest cities being Matola (1.7 million), Maputo, the capital (1.1 million), and Nampula (800,000). There are 0.07 physicians per 1,000 people and 0.7 hospital beds per 1,000 residents. (54) The country spends about $79 per person annually on health care, which represents about 7% of the country’s GDP. Life expectancy is 58 years for males and 62 years for females. (26) Maternal mortality is 318 deaths per 100,000 live births. (55)
The Associação de Anestesiologistas de Moçambique, with an address within the Hospital Central de Maputo, has 17 members and joined the WFSA in 2010. (25) There are 52 physician anesthesiologists working in Mozambique, 31 of whom work in the Central Hospital in Maputo. The remaining 21 are spread among 13 hospitals, of which 5 are located in the Maputo area. Of note, 19 of the 52 anesthesiologists are foreign providers working under government contract. There are also 257 anesthesia technicians working in a role similar to that of a CRNA in the United States. (56)

Mozambique has made great strides in the availability of medications on the WHO List of Essential Medicines. The Ministry of Health provides support for all the medications on the list, and, in 1999, the country implemented a Common Fund for Medicines and Medical Supplies to finance medicine procurement and pharmacy services. (56) From 1975 to 2007, the availability of medications on the WHO list increased eight times, from 10% to 80%. Remaining points of weakness in the system include the reliable availability of opioid analgesics. For instance, in the sole chronic pain clinic in the country, opioids were often stocked out and transdermal pain medications were unavailable. (56)

In a spot-check of hospitals in Maputo, a research group found that anesthesia machines, EtCO2 absorbers, and machines including pulse oximeters, blood pressure monitors, and EKG machines were available. Even in a survey of rural hospitals, they found that the operating rooms were relatively well-equipped and supplied. (56) In fact, when an evaluation was made of resources available in a group of hospitals in seven hospitals in the Zambesia province of the country, researchers found that the relative availability of oxygen, clean water, and electricity was an asset to the hospitals surveyed, while the greatest challenges were finding functional equipment, medications, and adequately trained anesthesia personnel. (23)
A closer survey of Maputo Central Hospital found that, in 2015-2016, 15 anesthesiologists were employed at the hospital, along with 27 anesthesia technicians. The team performed 10,897 anesthesia cases, of which 6,954 were under general anesthesia. The inpatient surgical mortality was 4.1 percent, although the majority were not necessarily related to surgery itself. Wound infection accounted for 2.7 percent of reported deaths. (57)

There is only one physician anesthesiology residency program in Mozambique. The training program requires 4 years in total, although Mozambique requires 2 public service years after a one-year general medicine internship after medical school, prior to beginning specialist training. This gap, coupled, with a lack of faculty, may account for the fact that, in past years, the residency program’s 4 spots have gone completely unfilled. Obstetric and cardiovascular subspecialty anesthesia training programs are technically available, but virtually no providers train in these programs. Licenses to practice are provided by the Ministry of Health and the Order of Doctors and graduates of the residency program receive diplomas in anesthesia and critical care. No continuing medical education is required of practitioners and no formal continuing education courses are offered. To become a non-physician anesthesia technician requires 1.5 years of nursing training, followed by 2.5 years to acquire “middle-level” training and an additional 4 years (for a total of 8 years) to acquire “superior-level” training. Training is offered by one school at each level. The “middle-level” training school graduates about 20-30 students per year and the “superior-level” school has a capacity to graduate 30 students per year. Licenses to practice are provided by the Ministry of Health at the completion of an exit exam. (56)

In summary, Mozambique has a growing population of anesthesia providers, although the training pipeline is not very robust, with a residency program which has gone unfilled in the past. Non-physician anesthesia providers, however, seem to be able to fill some of the gap, with a
relatively well organized curriculum and training programs. Strides have been made to improve medication reliability in the country and equipment seems to be relatively well-supplied. Based on this, it appears that improving the status of physician anesthesiologists and continuing to support non-physician anesthesia providers could be an effective way to improve anesthesia outcomes.

**Liberia.** Liberia is a country in West Africa, with a total population of just under 5 million people. About 52 per cent of the population lives in urban areas, which includes Monrovia, the capital (1.5 million). There are 0.04 physicians per 1,000 people and 0.8 hospital beds per 1,000 people. (58) The country spends about $98 per person per year, which accounts for 10% of GDP. Life expectancy is 62 years for males and 64 years for females. (59) Maternal mortality is 691 deaths per 100,000 live births. (60)

Liberia does not have a professional anesthesia society that is a member of the WFSA and there does not appear to be a physician anesthesiologist society in the country. This is likely due to the fact that there appears to be no physician anesthesiologists practicing full-time in the country. No graduate-level specialty training programs are available in Liberia, although the West African College of Surgeons does collaborate to provide some sub-specialty level training in select fields. The average county hospital, in a survey of 11 county hospitals covering about two-third of the national population, has 2 licensed anesthesia technicians and 0.5 unlicensed anesthesia technicians. Of necessity, physicians providing anesthesia care do not have formal training in the specialty. (41)

Liberia’s National Drug Service is responsible for the procurement and distribution of medications throughout the country and the Ministry of Health and Social Welfare is responsible for oversight of the public health sector. In a survey of 11 country hospitals, researchers noted
that medications on the government-issued formulary were variably available, with 9 of the hospitals reporting that shortages of medications occurred on a monthly basis. Storage of medications was less of a problem, because refrigerators used to store medications relied on solar power, rather than the central electricity supply. Antibiotics and anesthetic medications were relatively reliably available, although six hospitals said that they had an irregular supply of opioid pain medication. (61)

In the survey of 11 county hospitals, three of the 11 hospitals had piped, running water. Two hospitals had water “always” available, 7 had water “often” available, and 3 hospitals had water “infrequently” available. Five facilities had 24 hour electricity and there was a common reliance on the aforementioned solar power to meet electricity needs. Oxygen was available in each operating room in 9 of the 11 hospitals and a pulse oximeter was available in each operating room of 7 of the 11 hospitals. Post-operative units had pulse oximeters in 2 hospitals. All hospitals had some access to oxygen, usually provided via electric oxygen concentrators, although oxygen usually had to be shared among all of the units in the hospital. (61) It is estimated that about 31 percent of hospitals in Liberia have continuous access to electricity and that 25 percent have access to a continuous oxygen supply. (53) It is also estimated that 57 percent of hospitals have access to pulse oximetry and 17 percent have functional anesthesia machines. (53) In a study of 16 county hospitals and health centers, which were all outside of Monrovia, 3 facilities had running water. There were no physician anesthesiologists and 19 nurse-anesthetists. Ten hospitals had bag valve masks, 14 had blood pressure cuffs, 6 had hemostats, 8 had nasogastric tubes, 10 had sterile gloves, and 10 had sutures available. One facility did not keep medical records. (41)
In the 11 hospital survey, in 2009 there were 11 intra-operative deaths, which is the equivalent of 145 deaths per 100,000 surgical cases. The majority of the deaths were caused by intraoperative hemorrhage, which is exacerbated by the lack of readily available blood banking facilities. The authors of the survey study extrapolated that, within the 30-day post-operative period, the mortality rate is 1,359 deaths per 100,000 cases. The causes of death outside of the operating room, other than in cases of maternal mortality, are not routinely reported. Notably, reports of post-operative infections were unavailable, although one hospital was beginning to collect such data at the time of the survey. (41)

Interestingly, eight hospitals reported hosting outside groups, usually international non-governmental organizations, providing short-term surgical care, in the three years prior to the survey. (41)

In summary, Liberia does not have any physician anesthesiologists, which seems to be partially due to the size of the country. Adequate amounts of medications and supplies also seem to be an issue. There is some history of collaboration with larger outside organizations to improve the capacity of the country, such as with the West African College of Surgeons to increase opportunities for sub-specialty training.

**Rwanda.** Rwanda is a country located in Central Africa, with a total population of about 12 million people. About 17 percent of the population lives in urban areas, mostly in or near Kigali, the capital (1.1 million people). There are 0.13 physicians per 1,000 people. (62) The country spends about $125 per person per year on health care, which accounts for about 7.5% of GDP. Life expectancy is 66 years for males and 70 years for females. (63) Maternal mortality is 275 deaths per 100,000 live births. (64)
The Rwanda Society of Anaesthesiologists, headquartered at the University Hospital in Butare, has 19 members and joined the WFSA in 2008. (65) Recent achievements of the Society include holding a conference in 2015 focusing on maternal and newborn safety, where education, including information on Lifebox and the safe surgical checklist, was also provided. The Society also provided training to 195 healthcare providers across 5 district hospitals in 2014. (66) The average district hospital functions with no physician anesthesiologist and three anesthesia technicians. (42)

The national Ministry of Health has published a List of Essential Medications for the country. The supply and distribution of medications is centralized in the capital city, with a network of regional centers responsible for downstream distribution. In a survey of 21 district hospitals in Rwanda, about one-third indicated that they have further adapted the national list into one more appropriate for regional needs. Nevertheless, shortages of medications, including anesthetic medications, are common. For instance, in a list of the most common “stock-outs,” diazepam is the fourth most common medication to be unavailable. (42)

In the regional hospitals, which are smaller than the country’s referral hospitals, but still serve an average about 8,500 patients per year with an average of 195 beds each, electricity was generally available. However, the supply usually had to be supplemented with generators, which may not be sufficient to power all parts of the hospital at all times. Access to water, on the other hand, was good, with backup supplies relatively available. Oxygen was not reliably available, with compressed oxygen only available from the capital city. Oxygen concentrators, though, were present at all hospitals. Broken equipment was reported to be a significant problem and machines such as pulse oximeters and anesthesia machines were often out of service due to lack of qualified technicians and supplies. A common complaint was that technology provided by
outside sources (i.e., donated equipment) often did not come with proper training or instructions for use, leading to multiple broken machines, and misuse, underuse, and lack of use. (42) A later study that also included regional hospitals estimated that about 73 percent of hospitals in Rwanda have a continuous electricity supply and 75 percent of hospitals have a continuous oxygen supply. (53, 67) It is also estimated that 61 percent of hospitals have a functional anesthesia machine. (53) Using a WHO-based survey, researchers who surveyed Rwanda’s 44 district and referral hospitals noted that most hospitals used anesthesia technicians. Thirty-six reported having running water and 27 reported having a blood bank. Across all hospitals, there were 13 physician-anesthesiologists. Twenty-six had a continuous supply of endotracheal tubes, while 25 had continuous access to pulse oximeters. Thirteen hospitals had no ability to measure pulse oximetry. (67)

To become a physician, the National University of Rwanda offers a 6 year program leading to a bachelor’s degree, which allows for the practice of general medicine. As in other countries, 2 years of work is required of all new physicians at a hospital chosen by the Ministry of Health. Licenses to practice are issued by the Medical Council. There is no continuing education requirement for practicing physicians. For those who wish to subspecialize, including in anesthesia, a 4-year master’s program is available through the university. Partnerships with Canadian and United States organizations have been launched in an attempt to improve the quality of training. For non-physician anesthesia practitioners, the Kigali Health Institute offers a 3 year anesthesia technician program. Requirements for entry include a high school nursing degree plus one year of anesthesia experience. A bachelor’s degree program of 4 years’ duration is also offered in the country. In addition, some nurses practice in anesthesia without formal training. (42)
Due to Ministry of Health regulations, operating room mortality data is tracked and was available at the district hospital level when a survey was conducted. The twenty-one hospitals included in the survey reported 96 operating room deaths out of 10,289 surgical cases, presumably due to surgery and/or anesthesia, 9 deaths immediately after surgery attributed to anesthesia, 41 deaths immediately after surgery attributed to surgery, and 7 deaths occurring in the first 24 hours of the post-operative period attributed to surgery. The most common causes of deaths were hemorrhage and anesthesia-related complications (including respiratory issues caused by, among other things, high spinal levels). Consistent reporting was often hard to come by and the root causes of death were often unclear and many times not verified by autopsy. Limited monitoring often hid the true cause of death, although hemorrhage-related death was often attributed to a lack of banked blood. Sicker and decompensating patients were often transferred to referral hospitals, leading to likely underreporting of overall post-operative mortality. (42)

Interestingly, during the researcher’s survey, many non-governmental organizations were present and active at many of the hospitals they visited. They were involved in a number of different areas, which made it difficult to determine exactly what, where, and when they were contributing to care. It was also difficult to determine exactly how the organizations were chosen to come to the hospital and who authorized their presence. (42)

In summary, Rwanda seems to have a relatively robust anesthesiologist professional society. Medications and equipment still seem to be an area of need, including the lack of availability of blood banking. Partnerships have been launched in such areas of education and equipment provision, which may be a way to improve anesthetic capacity in the country.
**Chapter 5: Literature Review: Initiatives Launched.**

**World Federation of Societies of Anaesthesiologists (WFSA).** The WFSA recently celebrated its 65th year of existence. (13) With the mission “to unite anaesthesiologists around the world to improve patient care and access to safe anesthesia and perioperative medicine,” the organization now counts at least 136 societies representing more than 150 countries around the world among its members. (6, 68) The WFSA funds training opportunities through fellowships and scholarships and offers training, including teacher development workshops. In addition, the organization offers on-line tutorials such as Anesthesia Tutorial of the Week and e-Safer Anesthesia From Education modules. (69) It also disseminates information through various publications including the journals *Update in Anaesthesia*, as well as *Anesthesia and Analgesia*. (69) It helps promulgate international standards, such as the WHO-WFSA International Standards for a Safe Practice of Anesthesia Care, while working with multi-national humanitarian organizations, such as the WHO and the International Committee of the Red Cross. (70, 6)

**Lifebox.** In 2011, the WFSA, along with the Association of Anaesthetists of Great Britain and Ireland (AAGBI) and Professor Atul Gawande formed an organization called Lifebox in response to a need for pulse oximeters in many low- and middle-income countries. The idea behind Lifebox is to offer a high-quality technological product, supported with appropriate education to use the product, in an effort to improve anesthesia safety. (71) Some of the ways that make this project more cost-effective is by buying monitors in bulk and by maintaining direct contact between both the manufacturer and local organizations on the ground to negotiate lower pricing on the manufacturing end. Ensuring as seamless a transition as possible from factory to clinic and eliminating as many intermediate parties as possible are additional ways to
reduce cost. Follow-up at equipment delivery and at one-year post-delivery helps to ensure that issues are remedied in a timely manner and concerns are addressed. (72) In order to meet the educational needs of staff on the ground, each pulse oximeter comes with a DVD, as well as written literature, including a hypoxemia management algorithm and practice cases, as well as information on how to use and maintain the oximeter. These materials are supplemented by websites from the WHO and the Lifebox organization, which include additional information on hypoxemia management. Highlighting the role of local and regional organizations in the success of initiatives such as these, in-person training has been conducted in 50 countries, using contacts made through the WFSA with anesthesia societies and local clinicians. In an example of promoting the sustainability of the initiative, training also includes “train-the-trainer” workshops, offering the opportunity for local teachers to deliver content as the need arises. As of 2016, more than 10,000 pulse oximeters have been distributed to low- and middle-income countries, of which more than half went to countries in the African region. (71) A three to five month follow-up survey in Uganda indicated that 95% of the distributed monitors were being used and that knowledge retention of principles taught at equipment delivery was at the same level as that of the immediate post-test. (73) Anecdotal evidence of the Lifebox oximeter use can be seen in the case study data, for instance, the Lifebox oximeters being used in Ghana’s Konfo Anokye Teaching Hospital. (22)

**Educational Initiatives.** The WFSA has helped to develop anesthesia residency programs in Sub-Saharan Africa and initiatives to address training needs in the region have sprouted in countries such as Uganda and Rwanda. (74) In Uganda, for example, the Global Partners in Anesthesia and Surgery (GPAS) initiative is the result of a collaboration between teaching institutions in North America and Uganda. It is focused on workforce expansion, research, and
collaboration and has led to an increase in anesthesia trainees in one hospital program from 2 to 19 over 4 years. This was achieved in part by funding scholarships and other trainee pipeline programs, encouraging research reports to identify local needs and outcomes, funding local projects, and sponsoring an annual conference of non-governmental organizations in the area to coordinate efforts. (75) The Rwanda Human Resources for Health (RHR) Program has existed since 2019 and is led by the Government of Rwanda in collaboration with multiple teaching and academic institutions within the country and the United States. Its focus is to build the country’s health care workforce as well as increase the capacity of the country’s healthcare related academic institutions. Since the launch of the Master of Medicine in Anesthesiology training program in 2007, 13 trainees have graduated during the 2013-2017 time period and another 24 were still projected to graduate, having initiated their training in the 2013-2019 time period. Other related initiatives have included instituting continuing education programs for practitioners and recruiting additional faculty for local teaching institutions. (76)

More specific to anesthesiology training, in 2009, a partnership was launched between the governments of the United Kingdom (UK) and Zambia to form a new 4 year Masters in Medicine (Anesthesia) specialty training program, which began in 2011. Immediately prior to establishing the program, there was no post-graduate anesthesia training program in the country. Using volunteer faculty from the UK and Canada, a cohort of 8 physicians entered the first class. To promote sustainability, research was incorporated into the curriculum. Challenges in implementation included lack of knowledge about the student’s role, including conflict between surgery and anesthesiology, as well as resistance and lack of buy-in among already existing anesthesiologists. There was also concern about the broader recognition of the training
qualification after graduation. Furthermore, a general lack of equipment and supplies remained an impediment. (77)

As more and more trainees from high-income countries go to low- and middle-income countries to train and practice for varying lengths of time, standards for how to ethically and efficiently work in low-resource environments have become more robust. An overarching goal is that culturally appropriate care is provided in all circumstances and that benefit is obtained from all parties. Clinicians should only engage in activities for which they are trained. Other goals include clarifying objectives at the start of training, including regular updates and monitoring of these objectives during the participation, appropriate and quality training by vetted teachers, routine feedback offered in both directions of the training relationship, and the incorporation of ethics training into preparatory training. (78)

Task-Sharing. Task-sharing, otherwise known as task shifting, is described by the WHO as “[involving] the rational redistribution of tasks among health workforce teams [whereby specific] tasks are moved, where appropriate, from highly qualified health workers to health workers with shorter training and fewer qualifications in order to make more efficient use of the available human resources for health.” (79) A group of researchers looked at instances of task-sharing in low-income countries from 1996 to 2016. They found that, in many cases, task-sharing training was accomplished by utilizing health care personnel already trained in other areas and who were previously working on different tasks and using formal and informal education to allow them to perform a new, specialized role in anesthesia. This education could be offered through a variety of sites, from the local hospital to a central training center and could be supported by a variety of sources, from governments to religious groups to individual donors. Additional education could be provided via informal in-services or on-the-job training. (80)
Problems encountered with task sharing included issues with the quality and consistency of training, including the lack of a central and verified certifying, licensing, and accrediting body. Other issues included the inability to measure what skills had been learned by trainees and the availability of training programs. Researchers noted that learning opportunities for non-physicians were particularly hampered in training areas where physicians were also learning, as trainees were often competing for the same cases. A lack of clear roles between physicians and non-physician anesthesia practitioners was seen to be an issue, as well as concerns, particularly among physicians in surgical areas, about overlap in responsibilities and the desire for physicians to supervise their non-physician colleagues. (81) Lack of recognition of the talent and skill, full utilization of skills learned in the clinical arena, as well as poor pay are some of the major sources of dissatisfaction of non-physician practitioners in anesthesia. (82) To address the imbalance in numbers of anesthesia providers in rural versus urban areas, researchers have suggested that trainees from rural areas or with long-standing rural experience should be prioritized in the selection process. (82)

The issue of task-sharing is seen to be a forward-thinking way for improving health care outcomes, particularly in low- and middle-income countries. It has become so common, that the WHO has published a set of guidelines in order to delineate best practices in the field. Although originally designed as a way to maximize resources devoted to the epidemic of human immunodeficiency virus (HIV), the 22 recommendations made are broadly applicable to task-sharing in anesthesia, as well. Major themes of the recommendations include: involving all relevant stakeholders and including them for all major decisions, basing efforts on research done to identify areas of need, using regulations and law to delineate appropriate scope of practice for all professionals, developing measurable criteria by which training outcomes can be measured,
and providing adequate support, both monetary and professional, to those who receive training.

(79) These recommendations address, in broad strokes, some of the comments and concerns expressed above by workers already engaged in task training, thereby highlighting the importance of addressing these issues on a systematic basis to maintain a workforce that is long-lasting and competent.

**Chapter 6: Literature Review: Lessons Learned.**

**Role of professional organizations.** Societies, such as the WFSA, strengthen the anesthesia workforce and anesthesia infrastructure through advocacy and by creating strong partnerships with governments and decision-making organizations. (83) Professional organizations such as national and regional societies of anesthesia can set and implement curricula, collect data relevant to regional practice, and encourage recruitment of new anesthesia professionals through educational initiatives. Because they unite the voice of a single profession, they can be heard at a national level and set or influence national health care policy, thereby having an effect on population health. Not all countries or regions have a strong anesthesia society, whether that be due to lack of numbers, or lack of adequate resources. To address this problem, pairing local organizations with stronger neighboring societies, or societies in countries facing similar resource and infrastructure problems may be a useful way to increase participation in these types of organizations. Because projects to improve population health can take substantial funding and support, multiple stakeholders should be involved to increase the likelihood of success. These stakeholders come from a variety of sources and a variety of organizational and governmental levels and can include government agencies and ministries, hospital leadership, universities both locally and abroad, health care professionals, community stakeholders, patients and families, and professional societies. Because of the complexity of all these groups and potentially conflicting...
interests, the foundation for any successful project takes careful thought, preliminary planning, and time. (11)

**Using appropriately adapted equipment.** The Glostavent® is an anesthesia machine that was designed for the developing world. It is comprised of an oxygen concentrator, a ventilator, low resistance vaporizer, draw-over breathing circuit, uninterruptable power supply which functions even with voltage fluctuations, and a reserve oxygen cylinder. In the event of a power shut-off, the machine can sustain a patient using a standard size oxygen cylinder as both a source of oxygen, as well as a source of pressure to run the ventilator for up to 12 hours without additional input of power. Changes have been made to the original model over the years to address user feedback, including optimizing the oxygen concentrator and the power supply. (84) The current model, the Glostavent® Helix, comes with an oxygen concentrator, which can provide 10 liters of oxygen per minute and can be used with adults, children, and neonates. (85) Anesthesia machines which are of the draw-over type are generally preferred to those continuous flow machines common in high-resource countries because the former are usually portable, require minimal maintenance and use room air, as opposed to oxygen, to carry anesthetic gases to the patient. Oxygen concentrators, which have the capability of concentrating oxygen up to 95 percent from room air by passing it over zeolite to remove nitrogen may be a practical solution to using oxygen cylinders, which often need to be transported over long distances. Distinguishing what monitoring equipment is necessary versus not necessary is critical to keeping costs under control and managing resources efficiently. For example, EKG monitoring equipment is important, but because of relatively low rates of ischemic heart disease in Africa, as well as the need to have a reliable supply of electrodes, may not be absolutely essential nor particularly practical in a situation of shortage. Likewise, blood pressure monitoring equipment more
complicated than a manual sphygmomanometer is often not practical, due to the need to keep multiple sized cuffs and connectors available. Finally, overly complicated monitors, which require skill and time to maintain, calibrate, and repair, such as capnography, are also not useful and might only last a short time in a resource-limited situation. (86)

Considering storage conditions and the natural degradation of products, especially medications, is important when considering what drug and consumables (i.e., intravenous catheters, intravenous fluids, gloves, etc.) to supply. Many of these items are stored for long periods of time in varying, often non-ideal, conditions (in extreme heat or cold, for example, in humid areas, or in direct sunlight). Consumables which are intended to be one-time use only may be washed and reused. Thus, in selecting models or brands, the need for any special storage conditions (or at least knowing the harms which may arise from improper storage and what to look for), the durability and efficacy of the product when stored in less-than-ideal conditions, the potential for use past expiration date (and toxic degradation products), as well as the ability to be cleaned adequately for reuse, all must be considered. (86)

**Collaboration among Organizations.** As seen in some of the case reports (41, 42), humanitarian organizations are currently working in multiple settings and multiple capacities throughout Sub-Saharan Africa. While this can provide valuable human capital, as well as financial capital, humanitarian efforts may not always be responsive to the exact needs of a given region. Duplication and lack of organization of efforts are also a major problem. Often times, organizations work in independent silos, which can lead to a piecemeal distribution of resources. Individual organizations are often focused on assuring the success of their singular goal, whether that be to provide a given amount of resources to an area or to perform a set number of procedures within a given time frame. However, these organizational goals may not be the most
effective over the long-term, as they often do nothing to increase the local knowledge base or increase the capacity of the receiving hospital, community, or nation to help itself over the long-term. Also, traditionally, humanitarian organizations have not been focused on issues of sustainability of their efforts nor in coordinating care with other organizations which may have similar goals. Furthermore, sites for intervention are often chosen based on pre-existing knowledge of the region and personal relationships, rather than via a thorough needs-analysis, thereby awarding funds to the most vocal, well-known, or well-organized countries or organizations, rather than those with the most acute needs. This approach leads to interventions in convenient sites (i.e., that already have basic infrastructure in place or that are located in major cities) or intervening in sites at the insistence of a major donor. This can lead to exacerbation of pre-existing inequities between communities and hospitals or even reinforce political regimes. (87)

One way to avoid these pitfalls is to encourage collaboration among humanitarian organizations. This can most effectively be accomplished by doing a careful analysis of each potential organizational partner and identifying strengths and weaknesses. Ideal partners would have similar missions, but complementary strengths and weaknesses. Also important to take into account are the skills of the volunteers and workers in the organizations and pre-existing relationships. Each organization must be committed to forging true relationships with the other. Benchmarking is also a key step to ensuring that the work being accomplished is meeting goals. Forging alliances can help reduce waste and reduce cost. Sharing knowledge and experience among organizations and publishing results and acquired experience adds to the general knowledge base. Publicizing projects, such as through existing professional societies, can alert other organizations about what potential partners share a similar mission or may be in a nearby
area, thus expanding the network of resources. (87) Finally, encouraging the production of local research will help continue to call attention to the problems associated with providing anesthesia in Sub-Saharan Africa and promote high-quality, effective interventions in the region. (88)

An example of collaboration happened as part of the Strengthening Rwanda Surgery initiative. In this case, leaders from academic institutions, both local and from abroad, as well as from governmental and non-governmental organizations, a local professional organization, and a member of industry held an in-person summit to discuss the project and the needs of the local communities. This allowed multiple stakeholders with related objectives to set common goals, jointly establish next steps, and hear the voices and concerns of all interested parties. (89)

Chapter 7: Example of Anesthesia-Related Humanitarian Work Being Done in East Africa—Mark Newton, MD.

The work of Mark Newton, MD in East Africa highlights some of the themes presented in this thesis about how to effectively implement anesthesia capacity building strategies to meet some of the urgent needs in Sub-Saharan Africa. Dr. Newton is Professor of Clinical Anesthesiology at Vanderbilt University in Nashville, Tennessee and Director of Vanderbilt Global Anesthesia. (90) He has devoted a substantial part of his career to improving anesthesia care in East Africa and currently lives in East Africa full-time with his family. (90)

Dr. Newton was involved with a project to improve anesthesia human resource capacity through the implementation of an education program in rural Kenya to increase the number of nurse-anesthetists. (91) The program employed the principle of task-sharing by building upon existing nurse training and resources already present in the region and enhancing them to address the need for safe anesthesia care. Dr. Newton and his colleagues actively involved local officials
in order to ensure the acceptance of the future trained providers into the workforce, as well as to help increase the likelihood of the program continuing in the future, even without their direct involvement. They also made certain that the newly trained providers had the physical resources and support to do their work and used the principle of utilizing adapted equipment by making sure imported supplies world work in the hospital. For example, they made sure that the beds they obtained would function even with the hospital’s unreliable electricity grid and electrical current fluctuations. (91) The efforts of their careful planning are evident in the fact that, of the eighteen graduates of the program at the time of his report, all 18 continued to work in the rural hospitals that originally sent them for training. (91)

Another of Dr. Newton’s projects addressed the observation that mortality data in Sub-Saharan Africa is scarce and, often times, not systematically recorded. His team created a database to record anesthetic outcomes in a rural Kenyan hospital. (92) Specifically, they trained providers in the hospital to use an original-design computer-based tool to capture information about anesthesia and surgical case type, complications, and outcome, including intra-operative, 2-day, and 7-day mortality. Their success in including cases in the database was impressive, obtaining at least partial data on 71% of almost 12,000 surgical cases, increasing to 93% towards the end of the initiative reporting period. Dr. Newton and his colleagues were able to collect, analyze, and report results that benchmarked the hospital to averages of hospitals in middle- and low-income countries, as well as trends related to outcomes based on time of day of the procedure and the type of surgery performed. (92) These results demonstrate that, with systematic training and a concerted effort, tracking outcomes is feasible, and can often produce preliminary conclusions in a short period of time, which can identify areas of improvement soon after implementation. (92)
Dr. Newton has also been active in trying to reduce the rates of maternal mortality in East Africa through the development of a checklist tool designed to remind clinicians of best-practice processes when administering anesthesia during cesarean section. (93) His team specifically designed their checklist to be generalizable to hospitals offering varying levels of services: county-referral, subcounty, and district. In order to adapt the list to the region, assure sustainability, and demonstrate respect for the knowledge and the experience of the professionals already working there, they incorporated the input of a large number of East African providers in the refinement of the final document. What he and his colleagues noted when they observed 25 cesarean sections prior to checklist implementation was that only 75% of the items on the list were being performed, with an even lower number performed in emergent cases, suggesting that the tool would fill a clinical need. Furthermore, they did simulation cases with nurse-anesthetist students before and after they trained them on use of the checklist and noted a substantial improvement in the number of items being performed. (93) The checklist, thus, demonstrated a way to help improve adherence to best-practices in cesarean delivery, which should lead to improved outcomes in maternal mortality.

Chapter 8: Conclusion.

It should be clear from this thesis that the current state of anesthesia in Sub-Saharan Africa is insufficient to meet population needs. However, the causes of this are numerous: a lack of sufficient anesthesia practitioners coupled with a lack of necessary equipment, supplies, and medications, as well as a stark urban-rural divide. The result is high maternal mortality and surgical mortality and lowered life expectancy. Although establishing causation is challenging, especially with the current system of reporting, we can say that insufficiently resourced anesthesia practice and mortality are related. Case studies in various Sub-Saharan African
countries provide a picture of how few resources are available in many hospitals, including referral hospitals. Surgery is, nevertheless, still performed under these circumstances, meaning there is a critical need for anesthesia infrastructure and resources to help provide a measure of safety for those patients undergoing procedures. There are organizations working to close the gap between need and availability of resources, both human and material. Establishing networks of professionals and governmental organizations and harnessing the power of stronger organizations to assist organizations that are less well-off has been beneficial. Organizing strong anesthesia organizations on the ground and working on building human capital through education is one part of the solution, especially using technology and remote access solutions to innovate the dissemination of knowledge. With buy-in from all concerned parties, reorganizing manpower, with clear and well-delineated roles to best match skills to need is another way to maximize available resources. Providing key supplies and equipment with adequate education and supplies is a third. Strategies to adapt equipment to the reality of the situation, providing equipment that corresponds to the more urgent needs of the region, as well as encouraging collaboration among humanitarian organizations can help stretch limited resources. Finally, encouraging the active involvement of local professionals and organizations, providing tools that they can adapt to their needs, and modelling frameworks upon which they can start their own initiatives will hopefully encourage communities in the region to take ownership of their own anesthesia future and make it more sustainable.

References.


