Abstract: The global anesthesia crisis cannot be overstated. In the majority of low income countries and many middle income countries there are few if any physician anesthesia providers and little capacity for increasing the anesthesia workforce. At the same time, basic anesthesia monitoring is nearly universally lacking in most low income countries. As a result, surgical capacity is reduced with low intervention rates for emergency and essential surgical conditions, surgical safety suffers, and anesthesia and surgical outcomes result in unacceptably high disability and shocking rates of avoidable anesthesia mortality.

Tragically, low income countries have the highest burden of disease that can be averted through surgical intervention, and that surgical burden is increasing. Without adequate provision of safe anesthesia in these countries, little can be done to address the disability and premature death due to trauma, obstetric emergencies and greater incidence of chronic disease that contribute to the growing burden of surgical disease.

Global public health experts are only beginning to recognize the role of surgery within the scope of population health; and anesthesia needs to be recognized for its integral role in safe surgical care. This chapter reviews the public health concepts which apply to the global unmet surgical need and the anesthesia crisis which must be addressed.
To Whom it May Concern:

Please find the attached manuscript for the invited article: **Anesthesia and the Global Burden of Surgical Disease.** I am the sole author on this manuscript and all work is original. I have no conflicts of interest, and no financial or other relationships to disclose. Ethical standards have been maintained in the preparation of this document.

Kindest regards –

Kelly McQueen
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The Global Burden of Surgical Disease

Health indicators, established by the public health community and maintained by the World Health Organization (WHO) on a per capita basis by member country, reveal important details about the health of a population.\(^1\) Indicators are descriptive and generally non-specific, and have qualitative limitations. Health metrics are utilized to estimate the specific contributors to health within populations as well as the contributors to death and disability. The burden of disease, the contribution of a disease or group of diseases to the overall disability and premature death which exists in a population is a complex estimation reported in Disability Adjusted Life Years
(DALYs). The definition of the burden of disease is the disability or premature death that is attributed to the condition(s) on an annual basis. The attributed burden is reported in DALYs where 1 DALY is equal to one year of healthy life. The global burden of disease is a dynamic estimate of global health and is influenced by acute and chronic disease processes as well as by the interventions which impact or avert disease burden. These interventions include vaccines, medicines, and surgery.²

It must be emphasized that these methods of describing health and estimating disease are imperfect and assume that data can be collected, analyzed and applied. In much of the world today, especially in the low income countries (LICs) where a disproportionate amount of disease burden exists, even the most basic data cannot be reliably gathered. Death certificates for instance are common in the developed world, and are important to informing the mortality rates we rely upon to assess health and the value of interventions.³ But in many LICs, most deaths occur outside a hospital and without a diagnosis or post-mortem analysis. Even deaths that occur inside the hospital may not be accurately reported for a number of reasons, from the inability to provide a diagnosis to the political reasons that motivate a ministry of health or government to obscure the truth⁴.

Surgery is considered an important intervention for a number of diseases which have been defined as surgical conditions.⁵ But until recently the impact of surgical intervention on the Global Burden of Disease (GBD) had not been estimated. As chronic disease processes have increased in low and middle income countries (LMICs)⁶, Figure 1, it can be assumed that that the role of surgical intervention too has increased. Surgery provides treatment, cure, and palliation for many conditions, including cardiovascular disease, cancer, congenital anomalies, cataracts, and obstetrical complications. Improving the outcomes of these disease processes impacts the disability that results from delayed or unavailable surgical intervention. In addition there is a more obvious surgical impact on disability and death for emergency interventions such a cesarean section, trauma and acute abdominal emergencies.

In 2006, Debas et al estimated the burden of surgical disease (BoSD) to be 11% of the overall GBD.⁷ The BoSD is equal to the unmet surgical need in a community, country or globally.⁸ The initial estimate proposed by Debas and colleagues were an important starting place for including surgery in the greater global health agenda, but many experts now believe this to be an underestimation and hypothesize that the BoSD may be much greater⁹,¹⁰. Global health experts agree that the actual BoSD is largely unknown. Important steps are underway to apply global health concepts to the BoSD and to better estimate the actual unmet surgical need in LMICs¹¹,¹².

Global Surgical Volume is reported to be large. Weiser, et al, estimated that 234 million surgical procedures performed annually worldwide, and that a majority of these procedures are performed in high income countries.¹³ A majority of unmet surgical need occurs in LMICs where human, infrastructure and financial resources are limited, and many conditions which can be treated surgically are recognized late in
the nature course of the disease, therefore leading to greater disability and death. The World Health Report from 2006\textsuperscript{14} revealed that a majority of the burden of disease is found in Africa where the fewest health workers are found. Figures 2, 3. The most recent World Health Report, 2008, recognizes the increasing importance of surgery in LMICs, especially for trauma, obstetrical and abdominal emergencies.\textsuperscript{15} While access and infrastructure issues are important to overall diagnosis and delivery of surgery, the global healthcare worker crisis is also a critical contributor to unmet surgical need.

Most LICs have a critical shortage of surgical and anesthesia providers.\textsuperscript{16,17} While the World Health Organization (WHO) tracks numbers of physicians and other health care providers per country as a public health indicator\textsuperscript{18}, they do not report the number of specialists, such as surgeons and anesthesiologists, in a country. Recently a surgical assessment tool was published and available on the WHO Global Initiative for Emergency and Essential Surgical Services (GIEESC) website for use by interested researchers and providers.\textsuperscript{19} It is hopeful that this tool can provide increased information about surgical infrastructure and providers in LMICs, but few reports from the implementation of this tool are currently available. Even such large global organizations as the World Federation of Societies of Anaesthesia (WFSA) with input from many national anesthesia societies know little about the actual number of practicing physician and other trained providers, from all educational backgrounds, on a country basis.\textsuperscript{20} In 2008, members of the WFSA collected information on anesthesia providers in LMICs\textsuperscript{21}, but this critical report has yet to be published on the WFSA website or in a peer reviewed journal. Therefore, the little that is known about anesthesia providers is provided by ministries of health (MOH) or national health systems, or in some cases is reported by non-governmental organizations (NGOs) or individuals working in regions with critical need. Even without solid quantitative information, much can be inferred by overall numbers of reported physicians, hospital beds, life expectancy, and maternal mortality rates reported per capita by the WHO (Table 1.)

Anesthesiologists are a critical component of health systems infrastructure. As perioperative physicians, they provide quality, safe patient care in diverse settings. In LMICs, perhaps even more important than the clinical care they provide, anesthesiologists are responsible for the education and training of physician, nurse and other anesthesia providers who are essential to the maintenance of an anesthesia system which insures safe anesthesia outcomes and improved surgical outcomes. The success story of anesthesia safety within developed countries with good anesthesia infrastructure and requirements for monitoring are well known\textsuperscript{22}. Recent work by the WHO Safe Surgery Saves Lives\textsuperscript{23} further substantiates the role of anesthesia and a minimum of basic monitoring (pulse oximetry) in improving safety and decreasing adverse outcomes. Therefore the role of anesthesia is integral to the BoSD discussion and is critical to meeting the unmet surgical need through the delivery of surgical services.
The role of anesthesia within the BoSD is difficult to appreciate and even more difficult to measure in LMICs where anesthesia providers are critically limited, physiologic monitoring is often absent, outcomes are unknown and yet surgery continues. It is complicated by limited interest in anesthesia in many countries due to poor reimbursement and lack of professional respect, and by the available infrastructure considerations such as routine medicines, oxygen supplies, pulse oximetry and other monitoring equipment. History reveals that safe surgery with acceptable outcomes cannot be provided without adequate anesthesia providers and safe anesthesia equipment practices, and so to be completely addressed, the BoSD must be considered as a system: infrastructure, surgeons, anesthesiologists, nurses.

This chapter tackles the relationship of anesthesia to the GBD. While much is unknown, this is nonetheless an important and timely discussion. Inferences must be made from other public health indicators and applied to anesthesia, because safe delivery of anesthesia by qualified providers must remain central to the discussion of the unmet surgical need.

**Global Anesthesia**

There is an anesthesia provider crisis in most LICs and in many middle income countries. While little documentation of the crisis can be provided in terms of personnel and infrastructure, inferences can be made from the public health indicators and health worker statistics provided by the WHO. In many LICs there are fewer than 1 physician for every 100,000 people, compared with 19, 23 and 26 in Canada, the United Kingdom (UK) and the United States (US), respectively. In the poorest countries, those often ravaged by years of conflict and war, few doctors remain, no medical schools have survived and the care that is provided may come from a self-taught or self-declared providers, or from those who have learned “on the job.” In these countries it can be assumed that there are no physician anesthesia providers. A comparison of public health indicators is shown in Table 1.

The impact of the scarcity of physician and other health care providers is nonspecifically revealed by life expectancy at birth and maternal mortality rates (Table 1.) In LICs in Africa, where health workers are few and the GBD great (Figure 2, Figure 3), the life expectancy range is from 41 years (Sierra Leone) to 65 years (Comoros), with most LICs reporting life expectancy as mid forties to mid fifties. In comparison, Canada, the UK and US report 81, 80 and 78 years respectively. Of course, life expectancy is impacted by many factors, including those chosen by the WHO as Millennium Development Goals which include access to sanitation and clean water, decreasing infectious disease rates including HIV, and decreasing child and maternal mortality. Few indicators reveal the impact of physicians and skilled health care providers, including surgical, obstetrical and anesthesia providers as clearly as maternal mortality rates. Canada, the UK and US report death rates during pregnancy and following delivery at 7, 8 and 11 per 100,000 live births. LICs
in Africa report maternal mortality rates between 400 (Comoros) and 2100 (Sierra Leone) per 100,000 live births.

Death rates attributable to anesthesia and the lack of monitoring in LICs are largely unknown. Anesthesia in resource rich countries is incredibly safe, due to adequate numbers of physician personnel, supervision of non-physician personnel, requirements for monitoring and amply supply of medications, equipment and blood supplies. Anesthesia monitoring and vigilant personnel are anecdotally reported and witnessed to be absent or rare by international volunteers and others visiting hospitals and clinics in LMICs. But verified mortality rates from these countries are rare. The few published accounts have reported mortality attributed to anesthesia as high a 1 in 133 anesthetics, with other reports of avoidable anesthesia related death rates as high as 1 in 144 anesthetics, and 1 in 504 anesthetics. The UK based Confidential Enquiry for Perioperative Death reported mortality from anesthesia as being 1 in 185,000 anesthetics, revealing the true crisis in LICs. Of even greater concern is that many of the preventable anesthesia deaths occurred in otherwise young, healthy patients, many of whom were patients undergoing cesarean section.

The reported anesthesia mortality rates are a result of the few trained anesthesia providers in LICs, the limited monitoring available and the inadequate medication and blood supplies. A survey performed in Uganda in 2006 reported that only 23% of anesthesia providers had what they needed to provide safe anesthesia in adults, only 13% for the delivery of safe anesthesia for a child, and only 6% of providers could deliver a safe anesthetic for a cesarean section. A pilot survey from 2009 which attempted to quantify the anesthesia providers in low and lower middle income countries and outline their level of training, could obtain data from only 16 of 88 low and lower middle income countries. The challenges for revealing these numbers are many. In most countries where the data is lacking, there is an overall absence of technology and internal country communication. Anesthesia services may be provided even without the knowledge of or credentialing of the Ministry of Health. But even where the numbers of providers, their professional training and credentialing is known, there may be a hesitance on the part of the health ministry to share the details. The reality is often perceived as incriminating or embarrassing, and so the actual numbers of physician and other professional providers may not be accurately reported.

**Assessing the Global Anesthesia Crisis**

Efforts are underway to better describe the actual crisis in LMICs. A recent electronic pilot survey was attempted to more accurately describe the anesthesia provider crisis in LMICs. This study attempted to contact Ministries of Health (MOH) by email and through on the ground contacts in LMICs. The percentage of countries contacted and from whom responses were received was predictably low. However, this initial attempt
at an assessment by Dubowitz, et al reveals the challenges of quantifying the problem. The WHO is making an effort to collect data on anesthesia providers and infrastructure through the GIEESC assessment tool, but to date the assessment is performed by volunteers with interest and an organized system of completion in all LMICs has not been established or implemented. Concurrently, the WHO supports the provision of anesthesia by trained providers, and through several publications and collaborations provides guidance for the optimal provision of care. But to date the WHO has not provided detailed reports of ongoing anesthesia practices in its member states. The World Federation of Societies of Anaesthesiology (WFSA) too has an ongoing commitment to providing education and training for anesthesia providers in LMICs and has established International Standards for the Practice of Safe Anesthesia. While this large organization representing many national societies has collected information on the number of physician providers in 2008 from many LMICs, an absolute number of all anesthesia providers has not been collected as part of the efforts of the WFSA.

Providing accurate information on the global anesthesia crisis will better engage the global health community in addressing the disparity, and will advocate for improved infrastructure, a commitment to basic monitoring, and the provision of sustained training and education programs to serve LMICs. Improved data collection on anesthesia outcomes, including mortality rates, is essential. Without measuring outcomes and accurately reporting on the numbers and types of anesthesia providers in LICs, advocating for a global commitment to the crisis will be difficult. Accurate numbers of providers are a challenge in resource rich countries for many reasons including simultaneous licensing in many states and provinces, migration, and retirement with maintained licensure. But it must be recognized that without improved accurate information on anesthesia providers and training programs, advocacy efforts will be largely ignored by the global health community and by funding organizations that are engaged and motivated by statistical proof.

The Role of International Organizations and Non Governmental Organizations

International organizations (IOs) are reported to have significant budgets and many programs, including surgery, which may impact health in LMICs. IOs such as the International Committee for the Red Cross (ICRC) and Medicines Sans Frontieres (MSF), provide a large amount of surgery annually. In 2007 these groups respectively reported more than 100,000 and 50,000 surgical procedures mostly in conflict and post conflict zones, and in countries devastated by other natural and manmade disasters. Of interest is that while the surgery provided occurred in conflict zones, many of the procedures provided were for emergency and essential surgical conditions not related to conflict. The annual reports from these organizations revealed that many of the interventions provided were emergency obstetrical services and other emergency interventions not provided by the local health care system. In other words, these organizations are contributing to unmet surgical need. While the ICRC
and MSF represent the largest providers of international surgery, many other large organizations, including the United Kingdom (UK) based Merlin\textsuperscript{47} report not tracking overall procedures and with this in mind the global numbers may be much higher.

Smaller organizations referred to as non-governmental (NGOs) and private volunteer organizations (PVOs) also provide a significant and diverse amount of surgery worldwide.\textsuperscript{48} However, many organizations providing surgical services are not tracked by the international and humanitarian communities, and the only indicators of their impact may be the personal patient and family testimonies, and the end of year reports which reference overall procedures completed. A survey completed in 2008, contacted 100 NGOs providing surgical services overseas. This limited survey confirmed important quantitative details, and revealed that mid size and small organizations are interested in their outcomes even if these results are never published or communicated outside the board rooms of the organization\textsuperscript{49}.

The International Humanitarian Aid Community has an interest in surgical delivery in areas of conflict and natural disaster, as well as in underserved areas in LMICs. During the 2009 Humanitarian Action Summit (HAS)\textsuperscript{50}, the Harvard Humanitarian Initiative (HHI) looked at the role of surgical intervention in humanitarian intervention for the first time. The report of this summit includes consensus statements from the surgical group which met to consider the role of surgery in the delivery of humanitarian services.\textsuperscript{51} Future HAS will also focus on important issues of the surgical and anesthesia workforce, evaluation of outcomes and the role of NGOs in unmet surgical need.

It is hypothesized that IOs/NGOs/PVOs play an important role in unmet surgical need in LMICs and also in the education and training of anesthesia providers. But more information is required to evaluate the impact of these organizations, and their future role of addressing the global anesthesia crisis. To date these surgical IOs/NGOs and PVOs have focused their efforts on the delivery of services. While many organizations track case numbers and immediate outcomes for internal planning and quality assurance, few publish these results in peer reviewed journals and even fewer follow long term outcomes or share information outside the organization\textsuperscript{52}.

**Global Collaborations**

Several global collaborations have recently emerged as leaders in elevating the surgical agenda within global health. The WHO Global Initiative for Emergency and Essential Surgery Care\textsuperscript{53} (GIEESC) is leading the way in mandating the provision of surgery at district hospitals in LMICs and in providing training manuals and education to insure the implementation of the mandate. Another WHO initiative, Safe Surgery Saves Lives\textsuperscript{54} is focused on the safe provision of surgical services for the improvement of surgical outcomes. This initiative is advocating for the use of a pre-surgical checklist which insures communication among surgical team members, confirmation of the necessary resources for a specific procedure and the use of basic anesthesia.
equipment – the pulse oximeter. The Global Oximetry (GO) Initiative has been advocating for the provision and use of pulse oximetry as a minimum. A recent article in the Bulletin of the World Health Organization from the authors of the original checklist article of SSSLs, reported on a metrics application to surgical and anesthesia infrastructure. Efforts such as this may assist in estimating the unmet surgical need, the extent of the healthcare worker crisis, and the rates of death necessary to understand the disparity in LMICs.

The Bellagio Essential Surgery Group (BESG) is an important voice for unmet surgical need in Africa. The BESG is committed to raising international awareness to increase access to surgical services in resource constrained settings in sub-Saharan Africa. Their work is completed through cross-country collaborations, and in partnership with governments and agencies committed to addressing the surgical burden of disease. The BESG in collaboration with the WHO has also promoted the use of prioritization for the responsible delivery of surgical services in LMICs.

The Global Burden of Surgical Disease Working Group (GBSD WG) formed as a grassroots effort in 2007 among a group of motivated international surgeons, anesthesiologists, economists and public health specialists has focused its efforts on defining and evaluating the BoSD, prioritizing the delivery of surgical services in LMICs, supports humanitarian efforts and academic partnerships, and is working to address the obstetrical and anesthesia crisis which is at the center of the BoSD. The group has grown to more than 250 members representing many prominent academic institutions, international organizations and societies, humanitarian aid organizations.

Each of these initiatives and efforts is critical to the global voice for surgical intervention and safe anesthesia practices. But even as the work for evidenced based initiatives and the development of guidelines for surgery and anesthesia in LMICs continues, the absence of a binding obligation or mandate is still the reality. The efforts of the WHO while admirable are impotent without a commitment from ministries of health and national health care systems to build and maintain capacity to provide emergency and essential surgery and safe anesthesia practices.

**Academic Partnerships**

A new generation of physicians is in training in residencies and fellowships across the US, UK and other resource rich countries. These future anesthesiologists and surgeons have a documented and unprecedented interest in global health. Even the current and future medical students report a high interest in global health, and a desire to use their skills to work outside the US. Commensurate with these interests, schools of global health have been established on many medical school campuses throughout North America, and many global partnerships between US residencies and hospitals or programs in LMICs have been forged. Unlike IOs/NGOs/PVOs who primarily deliver services in low resource settings, these partnerships focus on improving infrastructure, and providing education and training.
A few academic partnerships have made long term commitments to low resource settings, and are partnering to improve the delivery of surgical services, as well as education and training of surgeons and anesthesia providers. Many of the US based programs in partnership with LMICs believe that education and training must be central to these programs, such that infrastructure will be improved along with the unmet surgical need being met. Including medical students and residents from resource rich countries offers a valuable exchange which is beneficial to all parties. Of course, cultural sensitivity is important as is delivering the services and education that the recipient country requests, not merely what the resource rich individuals or institutions believe the county should receive.

The future of these partnerships is unclear, but many international surgeons and anesthesiologists are hopeful for the sustainable education and training, improvement of infrastructure that is possible with these academic commitments. Of course as with all external interventions, measurement of outcomes and the impact of the programs are essential for evaluation and improvement.

**Society Partnerships and Commitments**

Many surgical and anesthesia societies have had a long term commitment to global outreach, education and training of surgical and anesthesia providers in LMICs. These partnerships and professional commitments are invaluable to the voice of the LMICs, and will advance the message of unmet surgical need in these countries.

The World Federation of Societies of Anesthesiologists (WFSA) represents 120 societies of anesthesia from around the globe. The objectives of the WFSA are to improve the standards of anesthesia worldwide, with a particular emphasis in developing countries. These goals are achieved through a commitment to education, publications, safety and quality. The WFSA has training programs in basic anesthesia, and in sub-specialty areas including pediatrics, obstetrics and intensive care. The collective voice of the WFSA is extremely important to raising awareness of the role of anesthesia within the BoSD.

The American Society of Anesthesiologists (ASA) has had a commitment to overseas teaching since 1991. An ASA member visionary, Dr. Nicholas Greene, was one of the first to report on the critical anesthesia needs of African countries. Dr. Greene had worked in Africa for decades, and was eventually able to convince the ASA to make a commitment to educating anesthesia “providers” in African countries with very few physicians. The official teaching efforts of the ASA in Africa were called The Overseas Teaching Program (OTP). The efforts of the OTP began in Tanzania, Zaire and Uganda, where few physician anesthesiologists existed. The legacy of this program is impressive, training many non-physician providers to deliver safe anesthesia in rural Africa and eventually to expanding anesthesia training programs and training residents in Tanzania, Ghana and Rwanda. Eventually, the OTP efforts combined with WFSA programs for training in Africa. Today, the OTP has expanded and has been
renamed the Committee for Global Humanitarian Outreach. While the mission of this new ASA committee has not yet been defined, the initial vision for the change includes a more global outreach, still with a commitment to education and training, but perhaps to advocate for the role of anesthesia in the provision of surgery worldwide.

The American College of Surgeons (ACS) has had similar vision. In recognition of the importance of these activities among its Fellowship, the ACS formalized its involvement by establishing the Operation Giving Back program (OGB) in 2004\(^6^2\). OGB provides an array of resources that facilitate and enhance humanitarian outreach to surgical patients and colleagues, whether through clinical care, training, educational partnerships and exchange, or by providing needed advocacy. The goals of OGB include defining the surgical humanitarian "ecosystem", understanding the contributions made on behalf of the surgical community, and illuminating gaps in need so as to better direct future efforts. Through a comprehensive informational web-based hub, OGB provides information on unmet surgical needs worldwide and directs surgeons to activities that optimize their skills and availability. ACS and OGB are integral members of the BoSD WG, and are active in contributing to the international literature.

The International College of Surgeons (ICS) was founded in 1937 as an organization dedicated to the furthering of surgical education and to the provision of humanitarian care worldwide. The College has organized national sections in over 60 countries and Fellows of the College come from all surgical specialties and related specialty groups such as anesthesia. Recently the US Section has emphasized the role of humanitarian care as a core mission and Fellows have participated in surgical missions to Sri Lanka, Iraq, Afghanistan, Bolivia, Ecuador, Honduras, Haiti and Ethiopia, among others. The global reach of the College allows Fellows from one country ready access to those of another and the personal ties that result have strengthened cultural and educational bonds between individuals and nations.\(^6^3\)

These societies play valuable roles in collaboration, education and advocacy. The WFSA, ASA and anesthesia efforts of the WHO are essential for insuring an improved future of adequate anesthesia provides and safe anesthesia practices within LMICs.

**The Global Public Health Agenda and Surgery**

Global Public Health is only beginning to recognize the role of anesthesia and surgery within the scope of population health. With chronic disease on the rise (Figure 3), and the role of surgical intervention recognized by the WHO and other organizations especially with regard to the impact of emergency obstetric surgery, trauma and other abdominal emergency surgical interventions\(^6^4\), it is only a matter of time before anesthesiologists and surgeons are critical members of the global health network. Advocates for the role of surgery and anesthesia include high profile members of the global community such as Paul Farmer and Jim Kim\(^6^5\) in Partners in Health, the World Health Organization and the initiatives in essential and emergency surgery,
trauma prevention, emergency obstetrical care and safe surgery, the humanitarian community, as well as many ordinary, committed anesthesiologists and surgeons working to increase access to timely surgical services, collect data for the evidence base of surgical care, and informing the literature on the role of surgery. A collective voice is also brought to bear through groups such as the Bellagio Surgical Group and the Burden of Surgical Disease Working Group.

Several important global health organizations have yet to recognize surgical intervention as an important strategy for the reduction of premature disability and death. These include the Gates Foundation and the Global Health Council. Anesthesiologists, Surgeons and the societies which represent them on a national and international basis must continue to provide the crucial data necessary to convince these global health giants of the role of surgery in global health, as well as the cost effectiveness and sustainability of many surgical interventions.

Many efforts have been realized. But much work remains. The role of anesthesiology in the delivery of surgery must be elevated in LMICs. The role of surgical intervention must be advocated for within the global health agenda. Basic to these causes is the quantification of unmet surgical need, verification of deaths related to surgical conditions for which delayed or absent treatment was rendered, and the establishment of anesthesia complications and deaths as relevant to the surgical burden.

Conclusions

With chronic disease, trauma and obstetric emergencies on the rise, the burden of surgical disease, or unmet surgical need, is rapidly growing, magnifying the inadequacy of available skilled anesthesia providers in LMICs. While global anesthesia literature is sparse, it reveals that preventable anesthesia deaths are extraordinarily and unacceptably high. Without international recognition of the critical role of anesthesia providers in averting premature disability and death, the global anesthesia disparity will only continue to grow. A commitment to anesthesia education and training, professional support for anesthesia providers through adequate compensation and societal respect, and a focus on safety as implemented through such initiatives as the provision of pulse oximetry in every operative site, is mandatory for every country. The developed world acknowledged the important role of anesthesia on surgical outcomes decades ago. The international community must now demand the same in LMICs. Disability and premature death will be impacted substantially with a global commitment to surgical intervention, but only if a commitment to safe anesthesia practices and adequacy of anesthesia providers also exists within the global health agenda.
Figures:

Main causes of death and global burden of disease (DALYs), world, all ages, projections for 2005

Figure 1. Death and DALY Projections.

Distribution of health workers by level of health expenditure and burden of disease, by WHO region

Figure 2. Distribution of Global Health Workers.
Figure 3. Global map of the distribution of physicians, midwives and nurses.
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*Table 1.* African Low-Income Country Health Indicators of interest to the Burden of Surgical Disease.
References


Personal correspondence with Dr. Angela Enright, President, WFSA, Oct 19, 2009.


31 Hansen D, Gausi SC, Merikebu M Anaesthesia in Malawi: complications and deaths Trop Doct 2000: 30; 146-149.


McQueen KAK, Hyder J


