

# Evaluating Progress in the Global Surgical Crisis: Contrasting Access to Emergency and Essential Surgery and Safe Anesthesia Around the World

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## Abstract

**Introduction** Since 2007, observations reveal that low- and middle-income countries (LICs and LMICs) experience similar surgical access and safety issues, though the etiology of these challenges varies by country. The collective voice of surveys completed to date has pushed the agenda for the inclusion of safe surgery and anesthesia within global health discussions. Comparison of four countries across the world shows similar basic progress as well as ongoing surgical and anesthesia needs in resource-challenged countries. By studying these common needs, a comprehensive plan to provide infrastructure and personnel support can work in multiple austere settings.

**Methods** A standardized survey tool published, designed, and developed initially by the Harvard Humanitarian Initiative and modified at Vanderbilt University was completed in Guatemala, Guyana, Laos, and Mozambique. The survey assessed eight key areas of essential surgical care: access to and availability of surgical services, access to human resources, essential infrastructure (including access to water, electricity, sanitation, blood products, and essential medicines including supplemental oxygen), surgical outcomes, operating room information and procedures, equipment, International Organization, and Non-Government Organization provision of surgical care. These results were compared and contrasted to evaluate resource challenges and assets in each country.

**Results** A total of 49 hospitals were surveyed in this comparison cohort. The results reveal common needs for emergency and essential surgery in each country, but some differences in human and capital resources exist. While minimal resources exist, all surgical sites provided running water, electricity, and oxygen—assets not seen in previous surveys as recent as 2011.

**Conclusion** The most basic needs to provide essential surgery are now present in LICs and LMICs. Many more resources are needed to ensure access to safe surgery and anesthesia. The next steps to provide essential surgery must include common solutions for access to surgery and anesthesia, and an evaluation of patient safety in these endeavors through the perioperative mortality rate.

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## Introduction

Safe surgery and anesthesia have long been appropriately prioritized in high-income countries as an essential part of health systems [1]. However, the global health community only recently prioritized emergency surgery, and previously considered essential surgery expensive and cost-ineffective for low- and middle-income countries (LICs and LMICs). Recent data support not only the cost-effectiveness of many basic surgical interventions, but also the strong impact of essential surgery on the global burden of disease, especially in LMICs [2].

The global burden of disease (GBD) has shifted from communicable to non-communicable diseases (NCDs) over the past 20 years. In fact, many global public health experts now recognize the important role of surgery in health systems, especially for leading causes of mortality: cardiovascular disease, trauma, cancer, and obstetrics [3]. The trend towards NCDs as the principle contributor to GBD is predicted to persist for the next several decades. Initial estimates from the 3rd Edition of the Disease Control Priorities Project suggest as much as 28 % of the GBD may be averted with surgical intervention [4]. Other estimates demonstrate the scope of the surgical crisis: two to three billion people worldwide do not have access to essential surgery, and 32 million people receive anesthesia without adequate monitoring annually [5]. Although there are 234 million operations performed worldwide each year, there remain significant disparities in who has access to these surgeries: the poorest 33 % of the global population receive only 3.5 % of these operations [6].

The reasons for this disparity and the ensuing global surgical crisis are complex and multifactorial. The World Health Organization (WHO), surgeons overseas (SOS), and the Harvard Humanitarian Initiative (HHI) undertook extensive efforts to document surgical and anesthesia infrastructure within LMICs. Countries in Africa, SE Asia, Central and South America were surveyed; the national medical education systems, health professionals, operating theaters, surgical and safety equipment were assessed and documented. Several articles compared the assets and needs of countries, which are as diverse as their geography. Even with the differences accounted for, limited access to emergency and essential surgery, primitive and absent anesthesia practice, breeches in patient safety, and unacceptable perioperative outcomes are common in LMICs [7–11].

Deficient infrastructure, lack of human resources, as well as lack of essential instruments, equipment, and medicines were identified as major barriers to meeting surgical need in developing nations. These initial surveys were vital in informing the early stages of the debate

regarding the global surgical crisis. Comparative studies that analyze surgical capacity in LICs and LMICs will document progress and create new strategies to address the global surgical burden. This paper compares four countries with similar World Bank designations and comparable health indicators across four distinct geographic regions. The infrastructure survey and comparison between regions offer insight into progress over the past 5 years along with ongoing disparities that these different regions have in common. These may be addressed through new initiatives to improve the ongoing disease burden. The surveyed countries for comparison are Guatemala (Central America), Guyana (South America/Caribbean), Lao PDR (SE Asia), and Mozambique (Africa).

## Materials and methods

A standardized survey tool designed and developed initially by the Harvard Humanitarian Initiative and modified at Vanderbilt University by the senior author was completed in four countries following IRB approval by Vanderbilt University and within each country surveyed. This survey tool was adapted originally from the WHO Tool for situational analysis to assess emergency and essential surgical care and has been completed in multiple LICs and LMICs. According to World Bank definitions, LICs have a gross national income (GNI) per capita of less than US \$1026 and LMICs have a GNI per capita between US \$1026 and \$4036. Essential surgery includes 44 procedures that address injuries, obstetrics, abdominal emergencies, cataracts, and congenital anomalies.

The survey assesses eight key areas of essential surgical care: access to and availability of surgical services, access to human resources, essential infrastructure (including access to water, electricity, sanitation, blood products, and essential medicines including supplemental oxygen), surgical outcomes, operating room (OR) information and procedures, equipment, international organization (IO), and non-government organization (NGO) provision of surgical care. Investigators completed these surveys in person at each site after visualizing resources. Capacity was confirmed with the hospital's medical director or equivalent.

The health indicators of each country were reviewed in WHO and other United Nations (UN) hospitals. Economic details of each country were obtained from the World Bank data, and health systems information was obtained from the Ministry of Health in each country.

Twenty-two hospitals were surveyed in Guatemala. The hospitals were randomly selected from a pool of 43 hospitals. Of the 43 public hospitals in Guatemala, five were omitted as they are geared towards mental health, rehabilitation, or other non-surgical services. A random number

generator was used to randomly select 22 of the remaining 38 hospitals, as time constraints precluded the ability to visit all locations.

Nine hospitals in Guyana were convenience sampled based on road accessibility due to poor infrastructure and difficulty reaching other areas.

Laos similarly convenience sampled 12 hospitals based on road accessibility. The 12 hospitals surveyed included all major capital city hospitals and three of the four provincial hospitals.

Seven hospitals in Mozambique were sampled in one province of the country, Zambesia. Since the country is large and road access remains difficult, the study was conducted in one province. All hospitals with surgical and C-section capacity were evaluated in this province.

## Results

A total of 49 hospitals were surveyed in this comparison cohort. The average hospitals/country surveyed was 12, 9 in Guyana, 21 in Guatemala, 12 in Laos, and 7 in Mozambique. The results of the individual country surveys are compared in Tables 1, 2, 3, and 4. The results reveal common needs for emergency and essential surgery in each country, but some differences in human and capital resources exist. Common assets include running water, electricity, oxygen, and the ability to sterilize surgical equipment across four countries. These basic provisions were previously lacking in other LMIC country surveys, indicating overall improvement.

Guatemala noted a plethora of surgeons, but inadequate equipment to perform surgery. The number for instrument

**Table 1** Basic national health indicators [12–17]

	Lao PDR	Guyana	Guatemala	Mozambique	USA
Life expectancy (combined M/F)	68	66	72	50	79
Infant mortality rate (per 1000 live births)	54	30	26	62	6
Under-5 mortality rate (per 1000 live births)	71	37	31	87	7
Maternal mortality ratio (per 100,000 live births)	220	250	140	480	28
C-section rate (%)	2	16.1	16.3	2	32.8

**Table 2** Comparison of surgical and anesthesia capacity [12–17]

Country	World Bank designation	WHO ranking (out of 190)	Greatest anesthesia asset	Greatest anesthesia barrier	Greatest surgical asset	Greatest surgical barrier
Guatemala	LMIC	78	Oxygen	Personnel	Operating rooms	Transport
			Clean water	Safety equipment	Personnel	POMR
			Electricity		sterilization	Adequate instruments
			PACU capacity			Operative log
Guyana	LMIC	128	Oxygen	Personnel	Sterilization	Transport
			Clean water	Safety equipment	Equipment	Personnel
			Electricity	Medications	6/9 operative log	POMR
				PACU capacity		
Lao PDR	LIC	165	Oxygen	Personnel	Sterilization	Transport
			Clean water	PACU capacity	Equipment	Personnel
			Electricity			POMR
			Medications			
Mozambique	LIC	184	Oxygen	Personnel	Instruments	Transport
			Clean water	Safety	Sterilization	Personnel
			Electricity	Equipment	Rural capacity	POMR
			Techs	Medications	building	
				Operative log		

**Table 3** Access and availability to surgical services (across surveyed hospitals)

	Lao PDR ( <i>n</i> = 12)	Guyana ( <i>n</i> = 9)	Guatemala ( <i>n</i> = 21)	Mozambique ( <i>n</i> = 7)
Mean catchment population	197,599	136,889	728,724	261,761
Estimated average distance to reach hospital (km)	36	60.8	64	42.4
Average number of operating rooms per hospital	1	2.1	5	2

**Table 4** Personnel capacity across regions (mean across surveyed hospitals)

	Lao PDR	Guyana	Guatemala	Mozambique
All physicians	18	12	50	4.8
Anesthesiologists	0.7	0.97	3.8	0
Anesthesia techs	0.4	1.3	4.5	1.4
OB/Gyn	1	3.42	6.7	0.57
Surgeons	2	0.75	7.8	1.29
Pharmacists	1	3.6	2.1	0
Pharmacy techs	2.3	6.66	10.5	4.71

trays did not meet the surgeon's needs. Thus, efficiency and operative capacity were compromised due to lack of equipment, not human factors.

Guyana had the basic common assets as well as the capacity to log operative cases in most hospitals surveyed. However, surgical capacity was compromised by lack of monitored post-operative recovery and personnel.

Lao PDR, contrary to Guatemala, has plenty of equipment, but not enough surgeons to utilize them. Facilities are lacking to monitor patients in a post-operative setting.

Mozambique surveys showed a lack of anesthesiologist and surgeons. Areas for post-operative care exist, but malfunctioning equipment is common. In addition, material resources were not available in the same location as trained hospital personnel. For example, one district hospital received new surgical and anesthesia equipment for two ORs that met or exceeded U.S. standard of care, but did not have a surgeon to utilize it, indicating inefficiencies in the allocation system.

Many common barriers to safe surgery are seen across the world. Transport to a higher level of care remains difficult for all surveyed countries. They reported poor road infrastructure and non-functioning ambulances that led to long transport times to definitive surgical intervention. None of the countries surveyed have the ability to track and report perioperative mortality rate (POMR), an indicator of safe surgery and anesthesia. Intraoperative deaths were not consistently tracked or documented. In addition, all countries noted a lack of trained anesthesiologists. Without appropriate anesthesia—which involves critical care during surgeries—advanced and many emergency surgeries cannot be performed.

## Discussion

Across the globe, a continued lack of access to surgery and safe anesthesia exists in LICs and LMICs. Surgical care is integral to universal health care, but progress significantly lags compared to other aspects of primary care in the poorest countries. Many NCDs including cancer and heart disease require surgical intervention to decrease disability and prevent death. Trauma burden is growing in LMICs, including all countries surveyed. Trauma contributes to disability and death with motor vehicle accidents being the most common etiology. All four countries are experiencing a surge in road traffic injuries (RTIs), with the largest segment of population (ages 1–44) suffering both disability and mortality. Surgical intervention and rehabilitation are often required to treat traumatic injury and both are limited or unavailable in rural areas of all four countries.

Access to emergency surgery during pregnancy is an indicator of the surgical capacity of a health system. Maternal mortality rate in each of the four countries surveyed is high despite prevention measures initiated over the past 15 years. The WHO guidelines for surgery at the district hospital specifically name C-sections as essential, with optimal C-sections rates at 5–10 % of pregnancies. Thus, safe anesthesia and surgery must be provided throughout the districts, with adequate personnel and equipment.

Resources for the provision of surgery and safe anesthesia have been shown to be cost-effective even for the poorest countries. At the present time, there are many gaps in equipment and personnel. However, availability of electricity, water, and oxygen for surgery is significant progress compared to recent assessment. Overall, surgical hospitals in all four countries have access to sterilization and operating instruments. While the number of autoclaves may limit surgical volume, the presence and upkeep of this infrastructure is required for effective surgical intervention, and all hospitals in this survey had access to these. Essential medicines described by the WHO include oxygen and are necessary for the safe provision of surgery and anesthesia, but are often limited or unavailable in LMICs. All four countries surveyed reported good access to oxygen and two out four countries surveyed had regular access to other essential medications including narcotics, anesthetics, and

antibiotics. Safe monitoring, especially pulse oximetry is a frequently cited gap in the provision of safe surgical care in LMICs. Mozambique, Guyana, and Guatemala reported that pulse oximetry is often absent or broken in many operative settings. Each country surveyed reported that absent or broken equipment generally limits the ability of both surgical and anesthesia staff to perform critical functions, and upkeep of equipment remains minimal.

Trained personnel are critically few in most LMICs. Adequately trained personnel to deliver anesthesia and surgery remain insufficient across countries surveyed. Specialists, including surgeons and anesthesia providers, are concentrated in large cities, and therefore, the greatest surgical disparity is found in rural areas, where much of the population lives. In Guatemala, 50 % of the population lives in rural areas and in Mozambique, 68 % of the population lives in rural areas. Mozambique had the fewest number of trained physicians of the countries surveyed. To counter this lack of personnel, task shifting is performed by training of technicians to perform a few number of surgeries, without the extensive medical training of a full physician. These technicians are utilized in rural areas to provide surgical and anesthetic care. Guatemala, by comparison, trained a plethora of primary care physicians but there are few general surgeons and anesthesiologists to deliver care related to trauma and emergency surgery. Specialists in Guatemala work in urban hospitals for which access is limited by transportation.

In Mozambique, similar to other LMICs, there is a focus in improving the capacity of rural hospitals. Designated rural hospitals had brand new surgical and anesthetic equipment along with new operating rooms; however, these hospitals were staffed with one or two surgical technicians, and no fully trained surgeons or anesthesiologists. Meanwhile, high-volume surgery centers with fully trained staff struggle with lack of pulse oximetry and malfunctioning equipment. Aligning appropriately trained staff with equipment is imperative to meet surgical need, and these disparities indicate problems with governmental allocation systems.

Broken equipment was common in most hospitals surveyed in all four countries. From surgical instruments, to X-ray machines, to OR suction, to centralized oxygen, hospitals expressed frustration with equipment dysfunction and lack of options for repair. No protocol to fix broken equipment or a consistent fund to pay for repairs existed. Consequently, many initial reports showed access to items such as ambulances, pulse oximetry, or cardiac monitoring; however, when asked to produce the item or demonstrate it, they were non-functional. Thus, it became important to specifically ask whether an item was working. As the surgical burden increases, a commitment to repair items through an organized process and the training of biomedical engineers or technicians will allow increased safety in surgery and anesthesia.

All four countries reported great difficulty transporting patients to a higher level of care. The highest level of care is found in central, urban hospitals; the rural populations found themselves without access to C-sections or basic, life-saving surgery. While lack of functional ambulances or a centralized emergency number contributes to this issue, lack of country infrastructure defines this problem. In Mozambique, the majority of people live in rural areas. Specialized care may require over 8 h of travel over rocky roads or multiple modes of transport including boats and buses. Many rural citizens do not want to leave their family for long travel times, nor do they have the funds to bring supporting family members with them. In Guatemala, the civil war wiped out rural capacity; thus, people must travel to the city on unsafe roads to access basic surgical care. Without a commitment to improving country infrastructure through road safety and development, an appropriate triage system for emergency surgery and trauma cannot exist.

As very basic tenants to health care are becoming standard across the globe, this four-country comparison proves similar needs throughout LICs and LMICs. Consistently noted at every hospital—a paucity of documentation, a lack of anesthesiologists and surgeons, inability to repair equipment, and transport difficulties. These four issues translate to unmet surgical needs, personnel, and infrastructure. The limitations of the survey include low volume and lack randomization on sites where infrastructure and access made randomization difficult.

Several sources of potential bias, including convenience sampling, affect the conclusions that can be drawn from these surveys. However, they also highlight the need for more information. The next step in improving our understanding of the global surgical crisis is to garner professional and international support to consistently collect and compare true nationwide surgical capacity, including mortality data. Continued statistical data are required for continued quality improvement projects.

Understanding the scope and limitations of surgical access are essential steps in finding effective solutions based on regional context. In addition, providing surgery and anesthesia safely with efficacy remains vital; documentation of perioperative mortality rates will shed light on this topic. The collection of perioperative mortality rates in most LMICs is a challenge, and these four countries surveyed are no exception.

## Conclusion

The description of surgical and anesthesia infrastructure on a country basis has informed the international literature and the global health community on the disparities contributing to the global burden. Progress is noted in improved basic



surgical needs such as accessible water, electricity, and oxygen, as well as sterilization of instruments. These infrastructure consistencies were not present 5 years ago. In contrast, personnel, infrastructure, documentation, and process improvement still need to be improved in most LICs and LMICs. Noting strengths, challenges, and successful solutions for the provision of safe surgical and anesthesia care may encourage collaboration for sourcing and the provision of rare resources such as Continuing Medical Education and biomedical support. The understanding of common assets and needs between LICs and LMICs can shape global health policy.

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