Strengthening the global surgical workforce: Aspects of access, migration and quality

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Aspects of access, migration and quality

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Strengthening the global surgical workforce

Aspects of access, migration and quality

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LUND
UNIVERSITY

DOCTORAL DISSERTATION

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Strengthening the global surgical workforce: Aspects of access, migration and quality

Abstract

Background. Over five billion people worldwide lack access to safe and affordable surgery and anesthesia care when required. There is a critical unmet need for surgical care, especially in low-income and middle-income countries (LMICs). The shortage of surgical providers is one of the most significant barriers to being able to receive surgical care when it is needed, and the maldistribution is aggravated by doctors emigrating to more affluent regions, where many physicians also nurture an interest in working abroad.

Aims and methods: The aims and methods of this thesis were:

I. To quantify the global supply and distribution of surgeons, anesthesiologists and obstetricians by country and to build a World Health Organization (WHO) surgical workforce database, using existing information and collecting new data through a cross-sectional study design;

II. To calculate the dependency of high-income countries (HICs) on recruiting surgeons, anesthesiologists and obstetricians from LMICs through a cross-sectional study design;

III. To measure the proportion of surgeons, anesthesiologists and obstetricians from LMICs who are now working in an HIC, by using a cross-sectional register study design;

IV. To quantify and analyze the surgical workforce in South Africa who were educated in another LMIC, and South African surgical specialists who have emigrated to an HIC, by using a register-based study design;

V. To investigate how LMICs perceive short-term visits from surgeons, anesthesiologists and obstetricians trained in an HIC, through a systematic literature review;

VI. To investigate Swedish orthopedic surgeons', anesthesiologists' and obstetricians' experience of, interest in, barriers to, and perceived value of international clinical work, and whether there were any differences in their responses, based on gender, specialty and seniority using a cross-sectional survey study design.

Results. There were two million specialist surgeons, anesthesiologists and obstetricians worldwide. Low-income countries had 0.7 such providers per 100,000 population (inter-quartile range [IQR]: 0.5–1.9), compared with 56.9 (32.0–85.3) in HICs. HICs' dependency on surgeons, anesthesiologists and obstetricians with a medical degree from an LMIC was 12%. Half of all surgeons, anesthesiologists and obstetricians who had emigrated from an LMIC to a HIC to work came from a country in workforce crisis. A substantial proportion of all surgeons, anesthesiologists and obstetricians from low-income and lower middle-income countries currently worked in one of the studied HICs (6.0% and 11.0%, respectively). Of all surgical specialists currently working in South Africa, 6% were educated in another LMIC. At least 16% of South African surgical specialists had emigrated to a HIC. Short-term visits by surgeons, anesthesiologists and obstetricians from HICs to an LMIC are insufficiently described from the perspective of stakeholders in the latter countries. Swedish orthopedic surgeons, anesthesiologists, and obstetricians have a broad experience of and interest in working abroad, and there are differences in their experiences based on gender, speciality, and seniority. Multiple personal and institutional benefits of working abroad were reported, with significant differences between LMICs and HICs. Participation is limited primarily by family commitments, followed by difficulties in finding the right contacts, medico-legal challenges, and fear of not having the right competence.

Significance. Most of the world's surgical patients are either operated upon by non-physicians or non-specialists, or they are not treated at all. This research has provided data on the global surgical workforce, focusing on access, migration and quality. Surgical workforce density has been acknowledged as a standard national health system indicator by the WHO, the World Bank, and The Lancet Commission on Global Surgery. It is currently used to track Sustainable Development Goal 3.8.1.

Key words Global Health, Surgery, Workforce, Access, Quality, Migration, International clinical work

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"It always seems impossible until it's done"

-Nelson Mandela

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List of publications

This thesis is based on the following studies referred to in text by their Roman numerals:

I. **Global distribution of surgeons, anaesthesiologists, and obstetricians.** Holmer H, Lantz A, Kunjumen T, Finlayson S, Hoyler M, Siyam A, Montenegro H, Kelley ET, Campbell J, Cherian MN, Hagander L. *Lancet Glob Health* 2015; 3(Suppl. 2): S9–11. doi: 10.1016/S2214-109X(14)70349-3. PMID: 25926323.

II. **International migration of surgeons, anaesthesiologists, and obstetricians.** Lantz A, Holmer H, Finlayson S, Ricketts TC, Watters D, Gruen R, Hagander L. *Lancet Glob Health* 2015; 3(Suppl. 2): S11–12. doi: 10.1016/S2214-109X(15)70084-7. PMID: 25926314.

III. **Measuring the migration of surgical specialists.** Lantz A, Holmer H, Finlayson SRG, Ricketts TC, Watters DA, Gruen RL, Johnson WD, Hagander L. *Surgery* 2020; 168: 550–7. doi: 10.1016/j.surg.2020.04.014. Epub 2020 Jul 1. PMID: 32620304.

IV. **South Africa and the surgical diaspora—a hub for surgical migration and training.** Rudolfson N, Lantz A, Shrime M, Johnson W, Smith M, Hagander L. *World J Surg* 2023; 47: 1684–91. doi:10.1007/s00268-023-06990-x.

V. **Systematic review of low-income and middle-income country perceptions of visiting surgical teams from high-income countries.** Velin L, Lantz A, Ameh EA, Roy N, Jumbam DT, Williams O, Elobu A, Seyi-Olajide J, Hagander L. *BMJ Glob Health* 2022; 7: e008791. doi: 10.1136/bmjgh-2022-008791. PMID: 35483711; PMCID: PMC9052057.

VI. **Swedish doctors operating abroad.** Lantz A, Velin L, Dahlin L, Hagander L. Submitted manuscript.

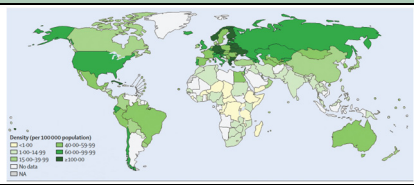
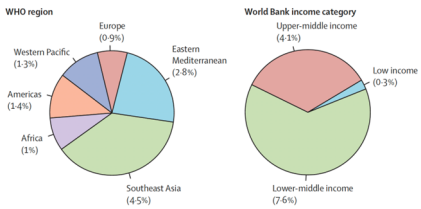
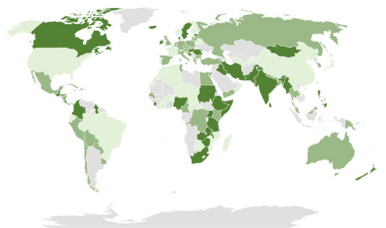
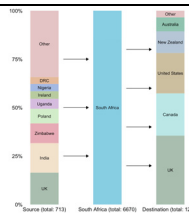
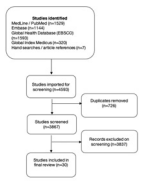
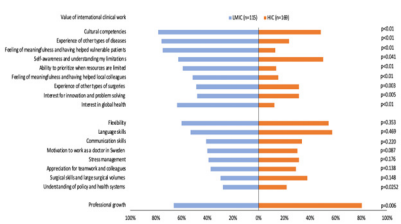
Abbreviations

AJOL	African Journals OnLine
aOR	Adjusted Odds Ratio
BESG	Bellagio Essential Surgery Group
CI	Confidence Interval (95% CI)
COSECSA	College of Surgeons of East, Central and Southern Africa
DALY	Disability-Adjusted Life Years
DCP	Disease Control Priorities
GBD	Global Burden of Disease
GIEESC	Global Initiative for Emergency and Essential Surgical Care Program
GIS	Geographic Information System
GNI	Gross National Income
HIC	High-Income Country
HPCSA	Health Professions Council of South Africa
IHME	Institute for Health Metrics and Evaluation
IQR	Inter-quartile range (25th-75th percentile)
LCoGS	Lancet Commission on Global Surgery
LIC	Low Income Country
LMIC	Low-income and Middle-Income Countries
MCAR	Missing Completely at Random
MDG	Millennium Development Goals
MeSH	Medical Subject Headings
NGO	Non-Governmental Organization
NSOAP	National Surgical, Obstetric and Anesthesia Plan
OR	Odds Ratio
POMR	Perioperative Mortality Ratio
PPP	Purchasing Power Parity
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
REDCap	Research Electronic Data Capture
SAO	Surgeons, Anesthesiologists and Obstetricians
SDG	Sustainable Development Goals
SFAI	Svensk Förening för Anestesi och Intensivvård
SFOG	Svensk Förening för Obstetrik och Gynekologi

SOF	Svensk Ortopedisk Förening
SOSAS	Surgeons OverSeas Assessment of Surgical Need
SSI	Surgical Site Infections
UHC	Universal Health Coverage
UNITAR	United Nations Institute for Training and Research
WBI	World Bank Income
WHA	World Health Assembly
WHO	World Health Organization
YLD	Years Lost due to Disability
YLL	Years of Lost Lives

Thesis at a glance

Study	Research question	Methods	Results
I	What is the global distribution of surgeons, anesthesiologists and obstetricians?	Cross-sectional observational survey of the number of surgeons, anesthesiologists and obstetricians per country. Multiple imputation to create estimates.	There are two million specialist surgeons, anesthesiologists and obstetricians worldwide. Low-income countries have 0.7 such providers per 100,000 population (interquartile range [IQR]: 0.5–1.9), compared with 56.9 (IQR: 32.0–85.3) in high-income countries (HICs).
II	How are HICs dependent on surgeons, anesthesiologists and obstetricians from low-income and middle-income countries (LMICs)?	Cross-sectional observational survey of HICs' numbers of surgeons, anesthesiologists and obstetricians with data on their country of initial medical qualification.	HICs' dependency on surgeons, anesthesiologists and obstetricians with a medical degree from an LMIC was 12%. Half of all surgeons, anesthesiologists and obstetricians who had emigrated from an LMIC to an HIC came from a country in workforce crisis.
III	What is the estimated proportion of surgical specialists from LMICs who currently work in an HIC?	Cross-sectional register-based study. We combined data from the World Health Organization Health Observatory data repository with data on the doctor's country of initial medical qualification from 14 high-income countries.	A substantial proportion of all surgeons, anesthesiologists and obstetricians from low-income and lower middle-income countries currently worked in one of the studied HICs (6.0% and 11.0%, respectively).
IV	What is the migration of surgical specialists in and out of South Africa and in absolute and relative terms to the size of the total workforce?	Cross-sectional observational study. We used data from a national registry of healthcare (The Health Professions Council of South Africa).	Of all surgical specialists currently working in South Africa, 6% were educated in another LMIC. At least 16% of South African surgical specialists had emigrated to an HIC.
V	What are the experiences and perceptions of LMIC stakeholders with regard to visiting surgical teams from an HIC?	A systematic review conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (PRISMA) and subsequent thematic analysis.	Short-term visits from surgeons, anesthesiologists and obstetricians from HICs are insufficiently described from the perspective of stakeholders in LMICs.
VI	What are the experiences, barriers and perceptions of international surgical work among Swedish orthopedic surgeons, anesthesiologists and obstetricians?	Cross-sectional survey study of all members of the Swedish Orthopedics Association, the Swedish Society of Anesthesiology and Intensive Care, and the Swedish Society of Obstetrics and Gynecology.	Swedish doctors have a broad experience of, and interest in operating abroad, with differences based on gender, speciality and seniority. Multiple personal and institutional benefits of working abroad were reported. Participation is limited primarily by family commitments at home.

	Figure	Conclusions
I		The lack of surgeons, anesthesiologists and obstetricians, especially in the poorest countries, contributes to poor access to and quality of surgical care.
II		HICs are considerably dependent on surgical providers from LMICs, and this deprives the latter of surgical capacity.
III		A considerable proportion of surgical specialists from LMICs now work in an HIC, and this is particularly the case for countries with a lower surgical specialist density.
IV		South Africa acts as a regional hub for surgical specialists' migration, both from LMICs and to HICs.
V		Visiting surgical teams from an HIC should consider local needs and opinions.
VI		Swedish doctors seem to have a broad experience of and interest in operating abroad, with differences found based on gender, speciality and seniority. Participation is limited primarily by family commitments at home. The perceived value of working abroad depends on the income class of the destination country.

Abstract

Background. Over five billion people worldwide lack access to safe and affordable surgery and anesthesia care when required. There is a critical unmet need for surgical care, especially in low-income and middle-income countries (LMICs). The shortage of surgical providers is one of the most influential barriers to receiving surgical care, and the maldistribution is aggravated by doctors emigrating to more affluent regions, where many physicians also nurture an interest in working abroad.

Aims. The aims of this thesis were: I. To quantify the global supply and distribution of surgeons, anesthesiologists and obstetricians by country and to build a World Health Organization (WHO) surgical workforce database. II. To calculate high-income countries' (HICs) dependency on recruiting surgeons, anesthesiologists and obstetricians from LMICs. III. To measure the proportion of surgeons, anesthesiologists and obstetricians from LMICs now working in an HIC. IV. To quantify and analyze the surgical workforce in South Africa who were educated in another LMIC, and South African surgical specialists who had emigrated to an HIC. V. To investigate how LMICs perceive short-term visits from surgeons, anesthesiologists and obstetricians from an HIC. VI. To investigate Swedish orthopedic surgeons', anesthesiologists' and obstetricians' experience of, interest in, barriers to, and perceived value of international clinical work, and to assess whether there were any differences based on gender, specialty and seniority.

Methods. To address these aims we: I. Collected existing and new data on the number and the distribution of surgical specialists globally. II. Collected details of the number of surgical specialists and data on their country of initial medical qualification who were now working in an HIC. III. Combined data on the number and the distribution of surgical specialists globally with the number of surgical specialists and their country of initial medical qualification now working in an HIC. IV. Collected data on the number of surgical specialists in South Africa and their country of initial medical qualification. V. Analyzed studies involving visiting surgical teams from HICs working in LMICs. VI. Surveyed all Swedish orthopedic surgeons, anesthesiologists and obstetricians.

Results. There were two million specialist surgeons, anesthesiologists and obstetricians worldwide. Low-income countries had 0.7 such providers per 100,000 population (interquartile range [IQR]: 0.5–1.9), compared with 56.9 (IQR: 32.0–85.3) in HICs. HICs' dependency on surgeons, anesthesiologists and obstetricians with a medical degree from an LMIC was 12%. Half of all surgeons, anesthesiologists, and obstetricians who had emigrated from an LMIC to an HIC came from a country in

workforce crisis. In low-income countries and lower-middle income countries, the proportion of surgical specialists abroad was 6.0% and 11.0%, respectively, compared with 1.2% and 3.0% in upper-middle income countries and HICs, respectively. Of all surgical specialists currently working in South Africa, 6% were educated in another LMIC. At least 16% of South African surgical specialists had emigrated to work in an HIC. Surgical short-term visits from doctors who underwent their training in an HIC are insufficiently described from the perspective of stakeholders in LMICs. Swedish doctors have a broad experience of, and interest in, operating abroad, with differences based on gender, specialty, and seniority. Multiple personal and institutional benefits of working abroad were reported, with significant differences found between doctors from LMICs compared to those from HICs. Participation is limited primarily by family commitments at home, followed by difficulties in finding the right contacts, medico-legal challenges, and fear of not having the right competence.

Significance. Most of the world's surgical patients are either served by non-physicians or non-specialists, or else they are not treated at all. This research has provided data on the global surgical workforce with respect to access, migration and quality. Surgical workforce density has been acknowledged as a standard national health system indicator by the WHO, the World Bank, and The Lancet Commission on Global Surgery. It is currently used to track Sustainable Development Goal 3.8.1.

Introduction

In many parts of the world, surgery is still invisible. Maybe death. Family members enter hospitals and never come out alive. Patients fear seeking care. Maybe it is too late, maybe their surgical condition is nothing. Maybe there are no trained surgeons to help. The medical costs, the iatrogenic financial catastrophe, and the impoverishment put the whole family at risk. Or they face the consequences of non-treatment. Surgery involves treatment for a broad spectrum of diseases, from acute to chronic conditions, and is required during all ages of life. But surgery is still deprioritized in health systems in many countries of the world as a result of the misconception that it is unrealistically dangerous and costly, Figure 1. Consequently, most people lack access to good quality surgical care, even though many suffer from treatable surgical conditions.

This thesis and the six associated manuscripts form a very small part of the infinitely large puzzle of how to implement the delivery of surgical care and public health. Before describing the purpose and aims of this thesis and presenting the methodology and results of the included studies, I will begin with a historical view on the evolution of surgeons. I will then present a short introduction to health and health systems, before narrowing this down to the role of surgery within global health, the global burden of surgical disease, perceived barriers in the access to surgery, and how we can measure the quality of surgical care at the population and health-system level. The six manuscripts focus on the shortage and maldistribution of the global surgical workforce, providing new data on aspects of access, quality, and migration. Finally, I will discuss the implications and impact of our results before outlining the study limitations and future directions.

Figure 1. Emergency surgery at Masanga Hospital, Sierra Leone. Photo: Adam Lantz.

The evolution of surgeons

Surgery began long before the introduction of anesthesia and antiseptics. The oldest operation for which evidence exists was a lower leg amputation performed in Borneo more than 30,000 years ago.[1] There are regional and local variations in historical surgical advancements, which have been influenced by cultural, social and economic factors.

In Europe, according to both the "*Iliad"* and the "*Odyssey"*, which were written in around 700 BC, physicians attended battlefields and helped wounded soldiers with pain management and they carried out radical amputations.[2] Physicians performed surgery. Later, when the concept of scholasticism was initiated in the Middle Ages, craftsmanship and surgery were considered to be barbaric disciplines, and they became separated from medicine. Surgeons were not viewed as "real" doctors, but were considered to be less sophisticated barbers, who were mostly trained for the battlefield.[3] The classification was dichotomous – physicians treated medical diseases and surgeons carried out operations. It was not until the Renaissance period in the 16th century that the Greek physician Galen was challenged by upcoming anatomists, and anatomical dissections gained medical attention. When Vesalius published his influential work "*De humani corporis fabrica*" in 1543, presenting detailed illustrations and descriptions of human anatomy based on his own dissections, it marked a significant shift towards empirical observation and accurate anatomical science. Vesalius advocated that all those performing surgery should engage in practical dissections in order to expand their clinical skills.[4]

Surgeons in England

In England, at this time, the knowledge and skills required for surgery were typically passed down through apprenticeship systems and were not standardized or regulated. Surgeons had no university education and were addressed as "Mr". In 1540, King Henry VIII merged together barbers and surgeons and established The Company of Barber-Surgeons.[5] Later in 1745 the two disciplines again went their separate ways, and the Royal College of Surgeons of London was established in 1800. In 1843, a new Royal Charter changed the name to The Royal College of Surgeons of England. Surgeons had to undergo examinations and aquire a formal qualification (Fellowship of the Royal College of Surgeons [FRCS], later Membership of the Royal College of Surgeons [MRCS]). Surgeons became proud to be distinguished from physicians and the title of "Mr" became a badge of honor. Even today, surgeons from the UK and Northern Ireland are addressed as "Mr" or "Ms".[6]

Surgeons in Sweden

Similar advancement in surgery was established in 1544 in Malmö, but under the flag of Denmark. It was not until the formation of the Collegium Medicum in 1663, following a resolution by King Karl XI, that people performing surgery had to undertake an examination in Stockholm, Sweden. The Collegium Medicum was directed by physicians and its aim was to formalize, increase knowledge and restrict those who performed surgery. The former board became the "Societati Chirurgicæ". In 1745, Olof af Acrel, the most influential surgeon and former President of the "Societati Chirurgicæ" and who is considered to be the father of Swedish surgery, authored a famous book on wound closure. He later became the first surgeon – behind closed doors to avoid attention – and was examined by and impressed of Carl von Linné at Uppsala University. Many years later, in 1788, Olof af Acrel was appointed as Sweden's first Professor of Surgery in Uppsala under the auspices of Carl von Linné. For interest, the corresponding professorship in surgery was established in Lund in 1801.[7]

Antiseptics, anesthesia and antibiotics

It was not until the 18th and 19th centuries that formal medical education became more structured and standardized and surgical training was incorporated into the medical curriculum. Following the work by Semmelweis, an early pioneer of antiseptic techniques, and Pasteur, who developed the earliest vaccines, the British surgeon Joseph Lister refined and founded the surgical aseptic technique and, together with Alexander Fleming's discovery of antibiotics, significantly reduced the risk of surgical site infections and adverse outcomes.[8] The development of anesthesia, from the use of opium and alcohol to ether, nitrous oxide, and chloroform – plus the discovery and implementation of postoperative pain management – enabled the development of new, safer surgical approaches, which was an important step forward.[9]

Technological era

The integration of modern technology and pharmacology into the surgical field during the last century has brought about a new era for surgeons, allowing for safer, more precise, and less invasive surgical procedures. This includes imaging tools: X-rays, computed tomography, magnetic resonance imaging, plus the development of minimally invasive surgical techniques, such as laparoscopic- or robotic-assisted surgery. In addition, pharmacological drugs have been developed, which can prevent, treat, or cure diseases that could previously only have been treated surgically. With that said, much of the advanced technical support and advancements in pharmacology are only available to a small percentage of patients living in high-income settings. Even today, in many parts of the world, people requiring surgery are still dependent upon

surgeons who are without, or only have limited access to, technical and pharmacological support.

Subspecializing

During this era of advancements in surgical care, the concept of the general surgeon, who managed everything, has been fractured into surgical subspecialties with the intention of acquiring quality skills through maximizing specific surgical exposure.[10,11] In Sweden, the available surgical specialties are anesthesiology, pediatric surgery, hand surgery, general surgery, vascular surgery, obstetrics and gynecology, orthopedic surgery, plastic and reconstructive surgery, cardiothoracic surgery, urology, ophthalmology, otorhinolaryngology and neurosurgery, which also tend to be split into their own specialty.[12] For example, orthopedic surgeons can choose to aquire fellowships in trauma, spine, foot and ankle, shoulder/elbow and sports, oncology, reconstruction, or pediatrics.[13]

In addition to physician subspecialization, health systems can be organized into where, and by whom, surgical services are delivered, in order to ensure high-quality surgical care. For example, surgical care that requires advanced training, multidisciplinary care, or high technological treatment, is increasingly centralized to tertiary hospitals, while surgical care that would benefit from being located close to a community, i.e. it is for more chronic conditions that require many healthcare contacts, or for extremely acute conditions, is becoming decentralized and is usually delivered at district hospitals.[14] Centralization of some surgical care is logical and rational. It is evident that some rare and complex surgical conditions requiring multidisciplinary care, e.g. cardiothoracic, neuro, transplant, neonatal or oncology, would benefit by relocating patients to high-volume centers. However, extrapolating evidence for the centralization of surgical services to surgical conditions with a less high-volume benefit may lead to devastating effects on the hospital surgical ecosystem and on surgeons' experience, competences and training. For example, in 2015, the report from the Swedish government: *"Practice makes perfect"* concluded that patient outcomes after surgical care, including survival rates, are a function of healthcare facility caseload volume of surgery and estimated that 500 patients may be saved in Sweden each year, if all surgery was performed in high-volume centers.[15] The conclusions were questioned from many angles and the extrapolated data were considered misleading and contributing to the drainage of resources from, and surgical competencies in, smaller hospitals.[16,17]

The introduction of subspecialization and centralization also results in less confident surgeons, with detrimental effects on their broader clinical and practical abilities.[18] The COVID pandemic further accelerated and aggravated the significant loss of operative experience for surgeons undergoing training.[19] For the individual patient, the

introduction of subspecialization and centralization may lead to them having a better postsurgical outcome with fewer complications, but it will also entail higher costs and require the skills of suitably trained surgical providers.[20]

Summary

The evolution of surgery has been exponential, from crude practice to the development of a sophisticated discipline that embraces new discoveries and continues to push the boundaries of science and what is practically possible. From barbers to physicians to general surgeons, and now sub-specialist surgeons, all integral components of clinical medicine and health systems for all. Evidently, surgeons' credentials have never been greater, but while the broad surgical skill sets of yesterday are becoming increasingly rare in high-income countries (HICs), most people in the world still cannot access adequate surgical care, when required.

Surgery in global health

Historically, health has developed dynamically and exponentially all over the world with the growth in the population, from its initial days of trial and error and spiritual beliefs, to the sophisticated and scientific solutions of today. It has evolved from the ancient civilizations, such as in Egypt, India and China, through the Renaissance period and industrialism, to today's scientific era.[21] Development and wealth are available to some people in the world today, while others still lack food and water for the day. Health systems act to improve individuals' health.

Health systems

Health systems are broad, complex and form an integral part of society. They encompass a wide range of interconnected components and processes that work together to deliver health to individuals and populations. The scope of this thesis will focus on health systems from the point of view of low-income and middle-income countries (LMICs). The WHO has outlined a framework based on six building blocks aimed at strengthening and assessing health systems: leadership and governance, service delivery, finance, infrastructure and products, information management and health workforce.[22] The purpose of health system strengthening is to define, assess, evaluate and improve these building blocks for health system performance, in order to meet the needs of populations.[23]

Health and healthcare efforts have long been directed towards reducing the burden of ill health through the implementation of preventive measures, early detection of disease and health promotion.[24] LMICs have greatly expanded patients' access to health

and healthcare services, which have saved the lives of millions of children, women and men, largely by preventing deaths from infectious, maternal and neonatal diseases.[25] Health achievements, in combination with an increased life expectancy and the epidemiological transition from communicable diseases to non-communicable diseases, have increased the focus and the need to address the burden of surgical disease.[26] The emerging health disease panorama, with its increasing need for surgical interventions for chronic and complex conditions, requires more than a single visit or standardized medicine package: it requires highly longitudinal and integrated health systems, with adequate numbers of skilled health workers. It is evident that access to healthcare can be an acute matter of life and death for the individual, and that access to essential quality treatment is needed in order to improve health outcomes for populations and sustainable development of nations.[27] Wars, conflicts and natural disasters can have detrimental effects on already fragile and neglected health systems in many LMICs.[28] The scope of this thesis will focus on surgical, anesthetic and obstetric care (hereafter termed "surgical care") from a baseline perspective of health systems, but will also acknowledge that it is equally important to consider disaster-related medicine.

Burden of surgical disease

The burden of surgical disease refers to the impact that surgical conditions have upon individuals, communities and health systems. Untreated surgical conditions condemn many patients to unnecessary suffering, handicap, marginalization, stigma and premature death. They could include obstructed labor, traumatic injuries, fractures, burns, correctable congenital anomalies, symptomatic hernias, cataracts, osteomyelitis, appendicitis, and much more. In particular, emergency surgery carries an added burden of risk because of the inability to plan or prepare for the procedure adequately and the logistical difficulties in gathering appropriate human, infrastructure and financially resources. Accordingly, outcomes are worse for emergency interventions compared with elective procedures.[29–31] Surgery is a cross-cutting specialty in health systems, with ill-defined borders, and includes more than just the operation itself. In order to be a functional surgical health system, it also requires additional services, for example pre- and postoperative care management, diagnostic tools, screening procedures such as X-ray, and pathology services, which makes it difficult to define.

The Global Burden of Disease studies (GBD), coordinated by the Institute for Health Metrics and Evaluation (IHME), have provided comprehensive estimates of the global burden of disease for over 30 years.[32] It uses data from various sources, including vital registration systems, surveys, hospital records, and scientific literature, in order to quantify the morbidity and mortality associated with specific diseases. The latest data from 2019 include information on 369 diseases and injuries from thousands of data sets.[33]

Unfortunately, the GBD studies did not consider surgical conditions as an entity, which has led to diseases requiring surgery being subsumed within other categories, such as infectious diseases, traumatic injuries or chronic health conditions. A standardized definition of the burden of surgical diseases was proposed in 2010, leading to the concept of met, unmet and unmeetable needs of surgical disease burden.[34] The burden of surgical disease is calculated as the sum of years of lost lives (YLL) and years lost due to disability (YLD), and is expressed as disability-adjusted life years (DALYs). In other words, one DALY is the equivalent of losing 1 year in good health because of either premature death or disability (DALY=YLL+YLD). The burden of surgical diseases can be avertable with prevention and better healthcare, or nonavertable, which implies that no matter what interventions are implemented, premature death or disability cannot be avoided. Very few LMICs have the capacity to collect, monitor or disseminate the appropriate data required in order to understand the local burden of surgical disease. Therefore, estimates are often extrapolated and modulated from small household surveys or from data acquired from HICs.

The Surgeons OverSeas Assessment of Surgical Need (SOSAS) survey has been used as a household survey tool in order to investigate the prevalence of surgical conditions within a population.[35] Studies from Sierra Leone, Rwanda, Nepal and Kenya have shown a surgical diseases prevalence, or unmet need of surgical burden, ranging between 12–25%.[35–38] Studies in HICs, with more accessible data, have shown that a total of 30% of all hospital admissions require surgery, a figure that ranges widely according to the particular medical condition that the patient has.[39] For example, 84% of all patients with any musculoskeletal disorder underwent surgery during their hospital admission, compared with only 0.4% of patients with a psychiatric disorder,.[40] In addition, Jarnheimer *et al.* showed that 8% of all infectious disease admissions were associated with surgery in Sweden, compared with a figure of 21% in South Africa.[41] Higashi *et al.* showed that 21% of injuries requiring surgery, which is the largest contributor to the global surgical burden, could be averted by addressing basic surgical care delivery in LMICs.[42]

Increasingly a number of global burden of surgical disease estimates have taken place, with different definitions and assumptions. The first, made in 2006 with data from 2002, and based on the experience of 18 surgeons, found that 11% of the global burden of surgical disease was avertable with surgical management.[43] The second attempt in 2015 was derived from assessing morbidity and mortality by scaling up a basic surgical package in LMICs. This method yielded a result of 14.2% of DALYs whose burden was related to surgical conditions. The same study estimated that 401 million DALYs/year were associated with a group of surgically treatable conditions, of which 285 million were nonavertable.[44] The latest estimate was conducted by Shrime *et al.* in 2015, who recognized that not all surgical patients necessarily require an operation, and

instead defined surgical disease as surgical care, which would benefit from the services of a surgeon in its management. They estimated that surgery is involved in the global burden of disease in 28–32% of cases.[45] The results were based on a survey of 173 responders with different background and healthcare positions. Notably, the estimated global burden of surgical disease surpasses the burden of HIV/AIDS, tuberculosis and malaria combined, Figure 2.[44]

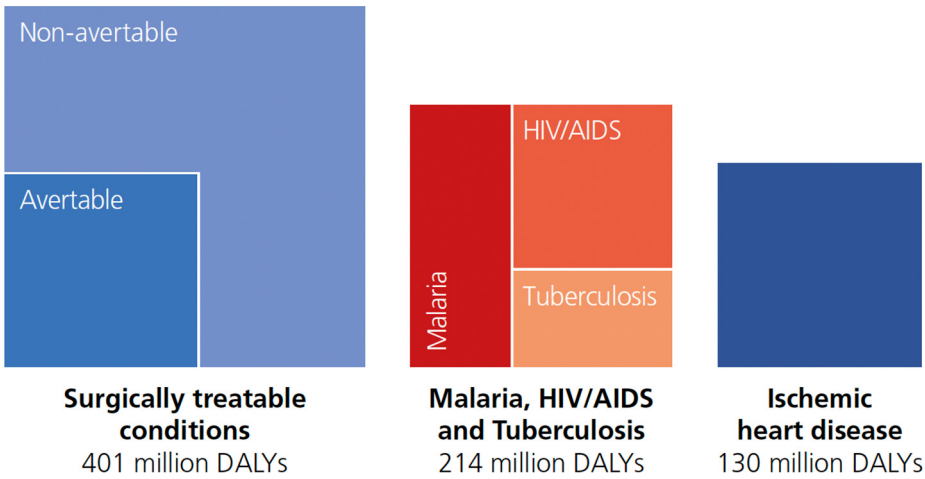


Figure 2. Disability-adjusted life years (DALYs) in low-income and middle-income countries (LMICs), for different groups of conditions (Adapted from Disease Control Priorities 3rd Edition, 2015, Volume 1: Essential Surgery).[44]

Barriers to surgery

Several barriers exist that hinder access to surgical care. Initially they were defined as three categories: acceptability accessibility, and affordability.[46] These were later expanded further to include timeliness and safety barriers to surgical care.[47] They can be addressed from a patient perspective, Table 1.

First, the patient must be aware that he or she requires healthcare, believe that healthcare would help them, and then be able to afford the indirect and direct costs of care. Second, the patient needs to be able to travel to and reach a healthcare facility within an adequate timeframe. Third, the healthcare facility needs to have the capacity and the right services available at an acceptable cost in order to prevent the patient from suffering financial hardship. Fourth, the surgical care needs to be safe and be of good quality. Lastly, the patient will require adequate rehabilitation to avoid further disability.[48–52]

Addressing these barriers requires a comprehensive approach involving health system strengthening, investment in surgical infrastructure and resources, training and retention of skilled health workers and financial protection mechanisms.[53–57]

Table 1. Different barriers to receiving surgical care from a patient perspective.[46,50,58]

Dimensions	Barriers
Acceptability	Culture or religion discourage surgical care Fear of undergoing surgery Lack of information that surgical care exists Mistrust of healthcare as a result of previous adverse events Personal beliefs concerning non-surgical alternatives
Accessibility	Geographical obstacles regarding travelling to the healthcare facility Insufficient healthcare facilities available in which to perform surgery Insufficient surgical providers Lack of materials or medications
Timely	Insufficient opening hours of the healthcare facility Waiting list at the healthcare facility Delay in receiving surgical care as a result of insufficient referral mechanisms Insufficient diagnostic or labaratory capacity at the healthcare facility The healthcare favility prioritizes acute surgical cases over elective operations
Safety	Insufficient anesthesia and postoperative monitoring Insufficient sterilization or medication No blood bank No surgical safety checklist Poor patient outcome
Affordability	Expensive care with high out-of-pocket payment No availability of healthcare insurance Travel expenses The need to purchase rehabilitation or medical/technical aids

Global Surgery

The former Director-General of the WHO, Dr Halfdan Mahler, played a key leadership role in engaging the surgical community when he emphasized the crucial importance of surgery and the need to achieve good health for all during his speech at the XXII Biennial World Congress of the International College of Surgeons in Mexico in 1980. He stated: "The vast majority of the world's population has no access whatsoever to skilled surgical care and little is being done to find a solution". Dr Mahler further highlighted the fact that access to surgery begins at the primary healthcare level and simple, essential surgical services should be provided by all health workers. He posed the question: "Are the surgeons of the world ready to give top priority to training of this nature, both for undergraduate and postgraduate doctors, nurses, and other types

of health worker involved, so that increasing numbers of people are proficient in providing essential surgery to all who need it?"[59]

However, decades later, surgery was still in its infancy. It was not until the WHO began the Global Initiative for Emergency and Essential Surgical Care Program (GIEESC) in 2005, with the aim of convening multidisciplinary stakeholders from different areas to promote surgery,[60] and the World Bank published the second edition of its Disease Control Priorities (DCP) in 2006 with a chapter on essential surgery and practical recommendations for priority interventions in LMICs, that surgery received attention within the global health field.[44] The following year, the Bellagio Essential Surgery Group (BESG) was formed and, in 2009, it published four recommendations on the improvement, strengthening and expansion of surgical services, workforce and delivery in LMICs.[61] Simultaneously, surgery gained momentum and was described as the "neglected stepchild of global health" by leaders in global health.[62]

In 2009, the WHO devised a program to implement a 19-item surgical safety checklist with the aim of improving team communication and consistency of care in order to reduce surgical complications and associated deaths. The results showed a significant decrease in surgical complications throughout different hospital settings.[63] Surgery became defined within the field of global health and the term "global surgery" was created.[64] A formal definition was later proposed by Dare *et al.,* Panel 1.[65]

Panel 1. Definition of global surgery by Dare *et al.*[65]

"We seek to define global surgery as an area for study, research, practice, and advocacy that places priority on improving health outcomes and achieving health equity for all people worldwide who are affected by surgical conditions or have a need for surgical care. Global surgery incorporates all surgical specialties, including obstetric and gynaecological surgery, anaesthesia, perioperative care, aspects of emergency medicine, rehabilitation, and palliative care and nursing and the allied health professions involved in the care of the surgical patient. It encompasses surgical care for underserved populations in all countries and for populations affected by conflict, displacement, and disaster, and promotes access to safe, quality care.

Global surgery recognizing supraterritorial and transnational issues, determinants, and solutions, recognizing that the determinants of inadequate or inequitable surgical care are often the result of common and interdependent global structures and processes, even though they are predominantly experienced within individual countries and communities. Global surgery involves many disciplines within and beyond the health sciences and promotes interdisciplinary collaboration, transnational partnerships, and multidirectional knowledge exchange. It is a synthesis of population-based approaches and individual-level clinical care."

The Lancet Commission on Global Surgery

In recognition of surgery becoming a global health priority, and in order to gain momentum in implementing better surgical care, in 2013, *The Lancet* launched a Lancet Commission on Global Surgery (LCoGS). This consisted of a multidisciplinary team of 25 commissioners, multiple advisors and collaborators, representing all continents and over 110 countries. It was led by Harvard Medical School, USA, King's College London, UK and Lund University, Sweden. Several meetings took place all over the world with the aim of catalyzing the work that then ended up in the report. Three official commissioner meetings were held: in Boston, USA, Freetown, Sierra Leone, and Dubai, United Arab Emirates. These meetings brought together not only all commissioners, but also the invited leaders, politicians, researchers and contributors, in order to provide in-depth analysis within the framework adopted from the WHO Health System Strengthening Building Blocks.[22] Commissioners were further engaged in direct outreach efforts at their respective ministries of health, and with implementers, funders, universities, societies, local organizations, communities, students and patients.[47] The LCoGS devised six key messages, two overreaching recommendations and six core health metric indicators, Table 2, in order to promote that "Universal access to safe, affordable surgical and anesthesia care when needed saves lives, prevents disability, and promotes economic growth". The two first studies in this thesis were integrated as part of the LCoGS.

Figure 3. The United Nations 17 Sustainable Development Goals provide "a shared blueprint for peace and prosperity for people and the planet, now and into the future."[66]

Table 2. Core indicators for monitoring universal access to safe, affordable surgical and anesthesia care when required. Adapted from The Lancet Commission on Global Surgery.[47]

Indicators	Definitions	Target by 2030
Access to timely essential surgery	Proportion of the population that can access, within 2 hours, a facility that can perform a Cesarean delivery, laparotomy, and treat an open fracture (the Bellwether Procedures)	A minimum of 80% coverage of essential surgical and anesthesia services per country by 2030
Specialist surgical workforce density	Number of specialist surgical, anesthesia, and obstetric physicians who are working per 100,000 population	100% of countries with at least 20 surgical, anesthesia, and obstetric physicians per 100,000 population by 2030
Surgical volume	The number of surgical procedures performed per year is an indicator of met need	80% of countries by 2020, and 100% of countries by 2030, tracking surgical volume; 5000 procedures per 100,000 population by 2030
Perioperative mortality	Surgical and anesthesia safety is an integral component of care delivery; perioperative mortality encompasses deaths in the operating theatre and in the hospital after the procedure	80% of countries by 2020 and 100% of countries by 2030 tracking perioperative mortality; in 2020, assess global data and set national targets for 2030
Protection against impoverishing expenditure	Proportion of households protected against impoverishment from direct out-of-pocket payments for surgical and anesthesia care	100% protection against impoverishment from out-of-pocket payments for surgical and anesthesia care by 2030
Protection against catastrophic expenditure	Fraction of households protected against catastrophic expenditure from direct out-of-pocket payments for surgical and anesthesia care	100% protection against catastrophic expenditure from out-of-pocket payments for surgical and anesthesia care by 2030

The WHO resolution on emergency and essential surgery

The official version of the LCoGS report was published in 2015, the same year that the World Bank released an updated version of the 3rd edition of the DCP, in which essential surgery, initially published as just a chapter, now comprised a whole volume. The LCoGS report covers various topics, from unprioritized surgery to details about practical steps and financial arguments to promote surgery within national health agendas.[44] Also in 2015, the WHO made it clear that surgery was a global health priority when the World Health Assembly (WHA) unanimously adopted the resolution (68.15) entitled: *"Strengthening emergency and essential surgical care and anaesthesia as a component of universal health coverage"*.[67,68] The same year, the United Nations adopted the concept of the 17 Sustainable Development Goals (SDG), based on the previous Millennium Development Goals (MDGs), in which surgery is highlighted as having a multidisciplinary role. Surgery is involved in many of the SDGs, and that improvements in the delivery of surgical care could contribute to achieving those goals, Figure 3.[66,69,70]

The definition of Universal Health Coverage (UHC) by the WHO is that: "All people have access to the full range of quality healthcare services they need, when and where they need them, without financial hardship. It covers the full continuum of essential healthcare services, from health promotion to prevention, treatment, rehabilitation and palliative care".[71] The three dimensions of UHC are: Who is covered? Which services are covered? And how much of the costs are covered, Figure 4?

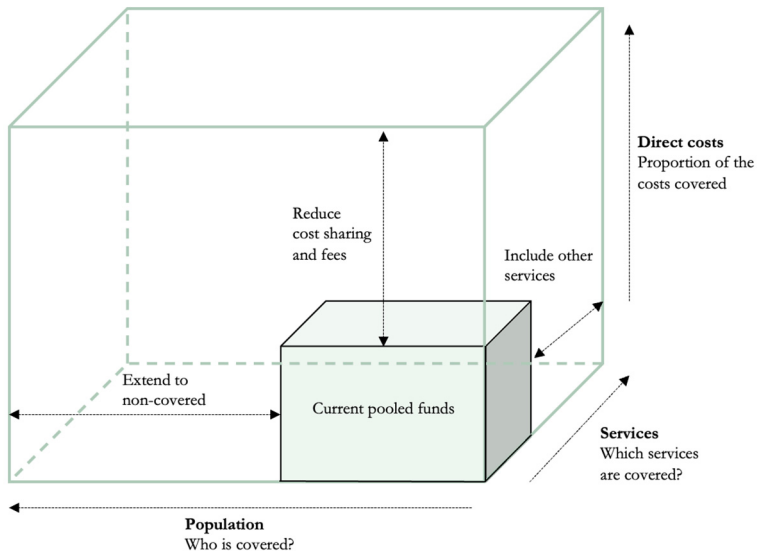


Figure 4. The three dimensions of Universal Health Coverage (UHC). Adapted from Boerma *et al*.[72]

Investing in surgery

Scaling up surgical services is necessary in order to decrease the burden of surgical disease in LMICs. This requires increasing the share of the income that is devoted currently to spending on healthcare, as well as implementing major investments in facilities and recruiting health workers. With financial constraints being imposed in many LMICs, investing in surgical services needs to be prioritized compared to other public health interventions. Cost-effectiveness analyzes are paramount, in order to consider both costs and health impact simultaneously, and are essential for making comparisons between diseases. The most common health benefit component to consider is the DALY.

The perception of surgery as an expensive and too complex intervention for patients in LMICs might have been a barrier to its acceptance within global health as an essential form of treatment and subsequent need for investment. However, studies have shown

that exactly the opposite applies. Surgery in LMICs is highly cost-effective, saves lives, improves the patient's quality of life and is affordable, both with respect to disease-specific factors (vertical), as well as its long-term ability to strengthen healthcare delivery (horizontal), compared to other medical interventions.[73–75] Another positive effect of surgery that is not included in cost-effective analyzes is its diagonal development within LMICs. For example, surgical missions to perform cleft lip surgery in children living in LMICs also strengthen the health system in that country through the development of surgical infrastructure and education of local health workers.[76]

The LCoGS estimated that the global macroeconomic impact of untreated surgical disease was $20.7 trillion, of which half this cost occurs in LMICs. The estimated investment required of $420 billion seems to have a substantial beneficial effect in terms of economics and health return in investment.[77] Several surgical interventions are listed in the 3rd edition of the DCP as being highly cost-effective, for example, those to treat obstructed labor, symptomatic hernia or a cataract.[44]

However, the true cost of the implementation and scaling up of surgical services is challenging to estimate, because of the necessary supporting systems required to do so, such as assistance from the departments of radiology, pathology, and anesthesiology, etc. In a few African countries, the cost has been estimated on a national scale to be $1–17 per person per year.[78,79] In comparison, current funding for global surgery is a fraction of that amount.[80–83] Advocacy, appropriate financial strategies and fiscal space on a political level are fundamental in order to scale up surgical services.[84–86]

National surgical, obstetric and anesthesia plans

Despite the increased awareness, discussion and research output regarding the provision of surgical care within LMICs, there are still multiple obstacles to be overcome in order to translate theory and existing knowledge into the provision of safe, affordable and timely surgical care for those who require it. The LCoGS recommended the implementation of national strategic plans that should be country- and context-specific, developed and owned by all national stakeholders, and lie within a broader strategy of improvement of health systems.

After the release of the LCoGS report, efforts have been made to integrate surgical care into political priority plans.[87,88] The National Surgical Obstetric and Anesthesia Plans (NSOAPs) have been developed to try and accelerate the process.[89] The NSOAPs utilize the WHO Health Systems Strengthening framework and building blocks that were developed in order to evaluate, create, implement, and finance specific surgical areas within national health systems.[90] The NSOAPs recommend multi-stakeholder involvement in order to improve surgical systems and a platform for a health systems approach to improve surgery, obstetrics, and anesthesia care and policies within the

wider health agenda. However, in order to promote the importance of global surgery, when it is in competition with other public health priorities, policymakers require valid, feasible and relevant health metrics, Figure 5.

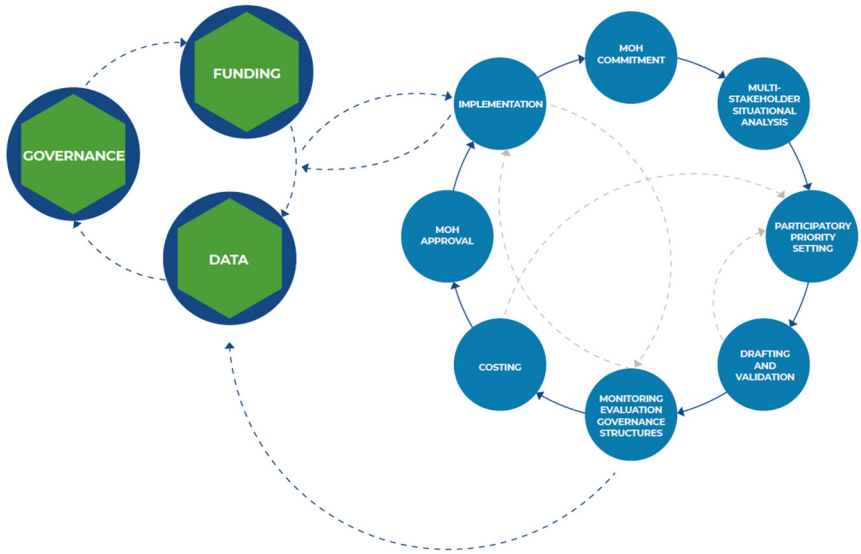


Figure 5. Steps for the development of national surgical, obstetric and anesthetic plans. Adapted from UNITAR.[91]

Global surgery metrics

Global health metrics have increased dramatically over the last few years and are paramount in the development of NSOAPs. Health metrics could be used to assess the current health status of a population, monitor progress, prioritize and allocate resources, evaluate health systems, inform and facilitate decision-making and enable international comparisons. Health metrics should be accurate, affordable, valid and easy to collect.[43]

It is impossible to achieve complete national data sets, which makes estimates and assumptions necessary for comparability purposes, and analyzing trends and for the progress of interventions or investments. Therefore, it is important to emphasize that the limitations and assumptions of the measured health metrics must be considered and handled appropriately, in order that adequate interpretation and implications can be made.[92] Not surprisingly, published data show major changes and discordant numbers depending on the different data sources, which brings into question the use of such data and the credibility of the sources.[93]

The LCoGS recommended a group of six indicators to measure and improve surgical care. These six indicators provide a framework within which the status of surgical care can be assessed and monitored, gaps in surgical care can be identified, and policy and resource allocation decisions can be guided in order to improve access to safe, affordable surgical care when required, globally, Table 2 above and Figure 6.[47]

Figure 6. The six Lancet Commission on Global Surgery indicators and targets by 2030.[47]

Indicator 1. Geographical proximity to hospitals performing essential surgery

Studies have shown that timing, and the geographical distance that the patient has to travel in order to access surgery, are important factors to consider in the prevention of disability or death from surgical conditions.[94,95] The term "access" has a wide definition, and includes many potential barriers that hinder the patient in receiving prompt surgical care. The LCoGS defines geographical proximity to timely essential surgery as the proportion of the population who can access, within 2 hours, a healthcare facility that can perform a Cesarean delivery, laparotomy and treat an open fracture (the Bellwether Procedures). The timeframe and surgical procedures were chosen carefully, and the LCoGS also highlights the fact that a mother dying of a post-partum hemorrhage requires surgery within this timeframe in order to avoid death. The Bellwether Procedures have been shown to be a good measure of surgical capacity.[96]

The most common method used to study the proposed indicator of geographical proximity to surgical care within 2 hours is the Geographic Information System (GIS) technology, which encompass not only travel distance, but also the infrastructure from the patient's location to the nearest healthcare facility which has the capacity to perform a Cesarean section, laparotomy, and treat an open fracture. This method has some limitations. First, the patient may not be able to travel via the quickest estimated route to the healthcare facility. Second, the patient may not travel at the recommended speed limits. Third, waiting times at the hospital may vary, depending on the capacity of the healthcare facility. Finally, the patient's acceptability of the need for surgical treatment is not considered in the model, and could delay transportation time. Studies have shown quite large time differences between GIS-estimated times and patient-reported times.[31,97–99]

Indicator 2. Specialist surgical workforce density

Based partly on the findings presented in this thesis, the LCoGS made recommendations on the minimum target for specialist surgical workforce density, which is the number of surgeons, anesthesiologists and obstetricians required in relation to a population of 100,000. A target was set that no country would have fewer than 20 surgeons, anesthesiologists and obstetricians per 100,000 people by 2030.[65]

Indicator 3. Surgical volume

In 2004, the total number of surgical procedures undertaken worldwide was estimated to be 234 million, a figure that was later increased in 2012 to be 313 million[103,104] The annual requirement for surgical procedures was found to be similar, and was estimated in 2015 to be 322 million surgical procedures, and 266 million in 2016, with overlapping confidence intervals (CIs).[100] Taking population growth into account, the annual requirement for surgeries was estimated to be 500 million surgical procedures in 2030.[101] The minimum target for surgical procedures was estimated to be 5000 per 100,000 population. In order to fulfil the minimum target, an additional 143 million surgical procedures need to be performed every year.[102] However, the rate of increasing surgical procedure volume remains slow.[79,103]

Indicator 4. Postoperative mortality rate

Patient safety is crucial when delivering surgical care.[104] Perioperative mortality rate (POMR) refers to deaths that occur during or immediately following a surgical procedure.[47,105,106] Postoperative mortality (deaths occurring within 30 days of surgery)

is the third leading cause of all deaths globally, after heart disease and stroke.[105] It is estimated that globally, 4.3 million people die within 30 days of undergoing surgery, and half of these deaths occur in patients living in LMICs.[107] While the definition is quite clear, the collection and interpretation of the results is more difficult, because mortality rates do not just depend on the particular operation that is carried out. Figure 7, adapted from Shrime *et al.*, shows that there are many different outcomes for patients with surgical conditions, both with and without treatment. In 2018, this was highlighted in an extensive systematic review,[108] and in the following year, another systematic review was published which included almost 8000 articles.[109] Both reports concluded that the POMR is an important health metric, but that further validation is required, and they emphasized the importance of using the same definitions for comparability purposes.[108,109] For example, the POMR is used for many purposes: e.g. to monitor and improve surgical safety, assess the impact of delay in accessing surgical care, and highlight poor quality of care and lack of resources.[110–112]

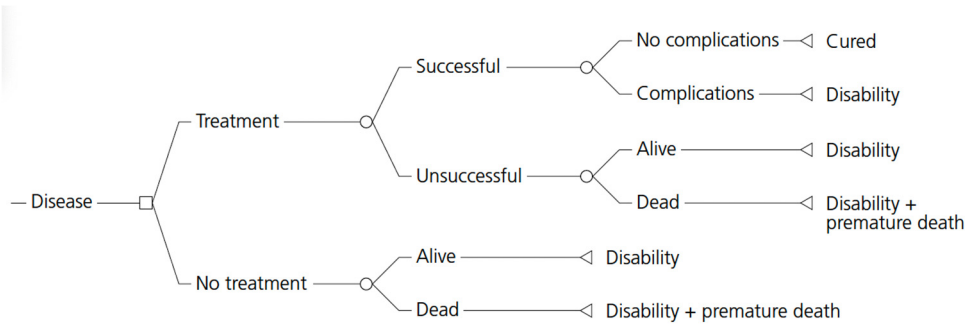


Figure 7. Potential outcomes of surgical treatment. Adapted from Shrime *et al.*[113]

There are many examples of the use of the POMR in different study settings, and in an African surgical outcomes study, values varied from 0.5–1.5% for maternal mortality, to 2.1% for all surgical interventions.[114–116] These figures are coherent with modeling studies for disease-specific interventions, such as for Cesarean delivery, appendectomy and groin hernia repair.[117] Another interesting and frugal methodology on global mortality from emergency abdominal surgery was conducted by the GlobalSurg Collaborative, part of the National Institute for Health and Care Research (NIHR) Global Health Research Unit on Global Surgery.[118] They undertook an international multicenter study, which included 10,745 patients from 357 centers in 58 countries. The results showed an overall POMR of 1.6%, and the POMR was found to be three times higher in people living in an LMIC, compared to those living in an HIC.[119]

The POMR is not an ideal measure of patient safety on its own, but it can be used as a proxy or an indicator of patient safety or quality of care in certain contexts. A major challenge with using the POMR to assess patient safety is that an individual healthcare facility, with a high-reported POMR, may lose its reputation and thereby patients as a result of fear of them developing serious adverse events, which is not necessarily true if the hospital performs a surgical procedure in a difficult case with a poor preoperative prognosis. Therefore, the LCoGS set the target of tracking the POMR instead of measuring the actual reported POMR. Further measures, such as recording the surgical volume, postoperative complications, readmission rates, patient-reported outcomes, and preoperative prognosis, should also be considered for risk adjustments in order to obtain a comprehensive assessment of patient safety and quality of surgical care.

Indicators 5 and 6. Protection against impoverishing- and catastrophic health expenditure

Impoverishing health expenditure and catastrophic health expenditure are related concepts that both highlight the financial impact and strain of health costs on individuals and households. Impoverishing health expenditure refers to healthcare costs that push individuals or households into poverty, or significantly worsen their economic situation.[72] Impoverishment occur when individuals, after paying healthcare costs, are pushed below the poverty line by Int$1.90 per day. Catastrophic health expenditure refers to healthcare expenses that consume a large proportion of an individual's or household's income or financial resources, but which do not necessarily push them below the poverty line. It occurs when expenditure related to treatment surpasses 10% of annual income.[120,121]

It is estimated that globally, one billion people spend more than 10% of their household budget on healthcare out-of-pocket payments, and 90 million people are being pushed into extreme poverty as a result of such payments.[122] It is estimated that one-half of the global population is at risk of financial catastrophe from having to undergo surgery. Each year, surgical conditions cause 81 million individuals to face catastrophic healthcare expenditure, for which less than half of the payments are attributable to medical costs.[123–125] Importantly, many people do not even seek healthcare treatment because they cannot afford it.[126,127] Financial risk protection is crucial, is adopted by the United Nations, and is covered by SDG indicator 3.8.2 in order to achieve UHC.[128]

Access

From a patient perspective, inadequate access to surgical care is fatal. The fundamental principle of surgery within the umbrella of global health is that people can access and receive safe and timely surgical care, without financial hardship. The LCoGS considered several factors – timeliness, capacity, safety and affordability – when they modulated data to estimate that 5 billion people lack access to safe, affordable and timely surgical care when required.[129] Alkire *et al.* devised a chance tree to assess global access to safe, affordable and timely surgical care, Figure 8.[130] Further research has shown that more than half of these estimated 5 billion people do not receive surgical care because they lack two of the above-mentioned factors, Figure 9.[131] Not surprisingly, most of the people without access to surgical care live in an LMIC. Solutions to accessing surgical care are multifold, but arguably, one of the biggest barriers is the shortage of surgical providers.

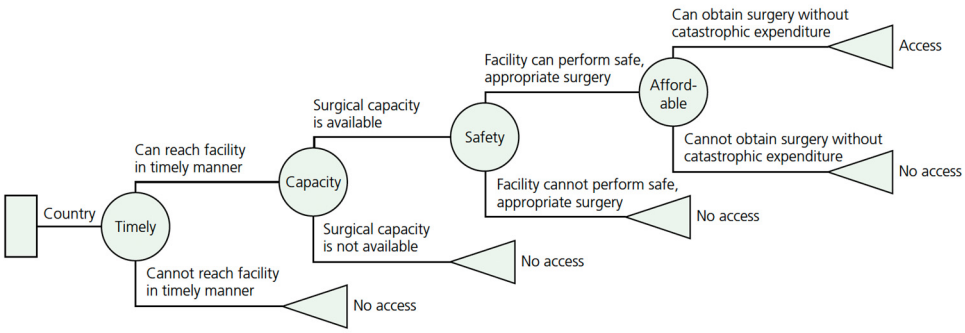


Figure 8. Chance tree to establish global access to safe, affordable and timely surgical care.[130]

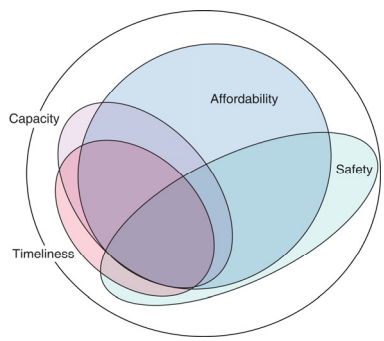


Figure 9. Area-proportional Euler diagram adapted from Rudolfson *et al*.[131] The large circle represents the total global population, and the smaller ellipses represent those who do not have access to surgical care, respectively.

Human resources for health

Human resources are paramount in all resilient and robust health systems and are the primary driver behind equity and economic growth.[132,133] The WHO defines health workers as "all those engaged in action whose primary intent is health". They encompass a diverse group of individuals with different responsibilities, characteristics, and technical expertise. Not only with regard to patient care, but also to health system planning, policy development, research, and other health-promoting initiatives.[134] The WHO has outlined a more holistic framework, rather than focusing on explicit numbers, regarding health workers under four domains: availability, accessibility, acceptability and quality, Panel 2.[135]

Panel 2. Framework of health workers, adapted from the WHO's report: *A universal truth: No health without a workforce*.[135]

Availability: Sufficient numbers of health workers with the right skills mix are required, who address the health needs of the population.

Accessibility: There needs to be equitable access to health workers. Factors to consider are the time required to access the healthcare facility, the cost of giving care, whether the facility is disability friendly, and whether there are adequate referral mechanisms.

Acceptability: Health workers must treat every patient with dignity and create trust, so that patients' expectations are met.

Quality: Health workers must have the right competencies and skills, and perform their duties according to professional norms.

The number of available health workers is difficult to assess, as a result of variations in definitions, classifications and data collection methods between different countries. However, according to recent data, the global supply of health workers is estimated to be 104 million, and the global needs-based shortage is estimated to be 43.2 million health workers. The proportions are similar to those of physicians, for whom there is a global supply of 12.8 million and a global needs-based shortage of 6.4 million physicians required to achieve UHC.[134,136] The shortage of health workers is global, but is felt most acutely in countries that need them the most, generally in LMICs.[137]

Health workforce crisis

The distribution of health workers is distributed highly unevenly, with a greater percentage working in HICs and urban areas, compared to in LMICs and rural areas, Figure 10. In 2006, the WHO identified 57 countries that were in particular health

workforce crisis.[133] This conclusion was drawn from correlating health workforce density with a requirement for a minimum of 80% attendance at births by skilled birth attendants. The WHO's report was revised in 2020,[138], and then updated in 2023[139] using a new methodology that encompassed the UHC service coverage index, the official SDG 3.8.1 indicator, and health workforce density, the official SDC 3.C.1 indicator, with the aim of supporting 55 countries which were found to be in particular workforce crisis.[140]

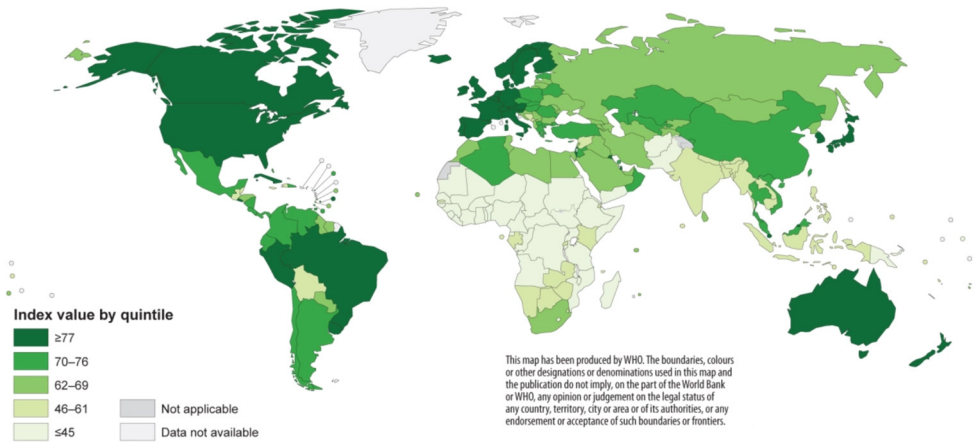


Figure 10. Universal Health Coverage Service Index from 2015: In order to track progress towards achieving UHC and SDG 3.8.1, and compare performance across countries, the World Bank is using an indicator which covers essential health services: namely reproductive, maternal, newborn and child health (RMNCH), infectious diseases, noncommunicable diseases, and service capacity and access including surgeon density. The indicator is a weighted index of 14 different health services reported on a unitless scale of 0 to 100.[141]

Most of the countries that are in workforce crisis have the highest burden of disease, high population growth and a shift from communicable to non-communicable diseases. These factors, when combined, challenge the countries' already fragile health systems, which were not built to absorb the increasing need for health workers and address the backlog of disease burden. The shortage of health workers is also often exacerbated by migration, war or political instability, violence towards health workers, and insufficient financial support to retain them. Today, health workers throughout the world are better educated, and more assertive in accessing information, education, and professional development – factors that contribute to them mitigating mobility and migration.[142–145]

Surgical workforce

In order to be a functioning health system that includes access to surgical care, it is essential that there is an appropriate team available to support it. There are many essential health workers required beyond the operating room. In order to address the critical burden of surgical disease, someone needs to hold the scalpel. It is not just surgeons, anesthesiologists and obstetricians who perform safe surgery and deliver obstetric care. In many parts of the world, it is quite often a physician without any formal accreditation in surgery, anesthesia or obstetrics, a non-physician, clinician or nurse who performs the operation.[146,147] There are unfortunately no global data on the number of health workers performing surgery. This information is too difficult to record, because there is no clear description or definition of such health workers. Nonetheless, the paucity of surgeons, anesthesiologists and obstetricians in most LMICs limits both the access to and quality of surgical care. It is obvious that many countries lack suitably trained health workers who can perform safe surgery, especially in the poorer countries, which have the highest burden of surgical disease.[148,149] However, there are no global data on the number and distribution of surgeons, anesthesiologists and obstetricians.

Research QI: What is the global distribution of surgeons, anesthesiologists and obstetricians?

Migration

The critical shortage of health workers throughout the world also depends on global maldistribution and imbalance between increasing demand and faltering supply. An estimated 15% of all health workers practice outside their country of birth or first professional qualification.[150] The situation of the acute shortage of health workers in many LMICs will most likely deteriorate in years to come, because future projections indicate the accelerating international emigration of such workers to HICs. In addition, there are financial constraints in LMICs that preclude the expansion of education programs.[151,152]

Physician migration and the subsequent depletion of specialist personnel in LMICs is a common concept, whereby trained physicians move to more affluent regions. A study showed that, of the existing physician workforce in the USA, UK, Canada and Australia, 23–28% are medical graduates from overseas. In other words, one-quarter of all the physicians in these countries come from LMICs.

Migrated physicians form a significant proportion of the total number of physicians in source countries.[153,154] LMICs with smallest numbers of physicians are most affected

by such migration.[155–159] The direct economic effects and excess patient mortality that arise from this situation are devastating for LMICs, Figure 11.[160–163]

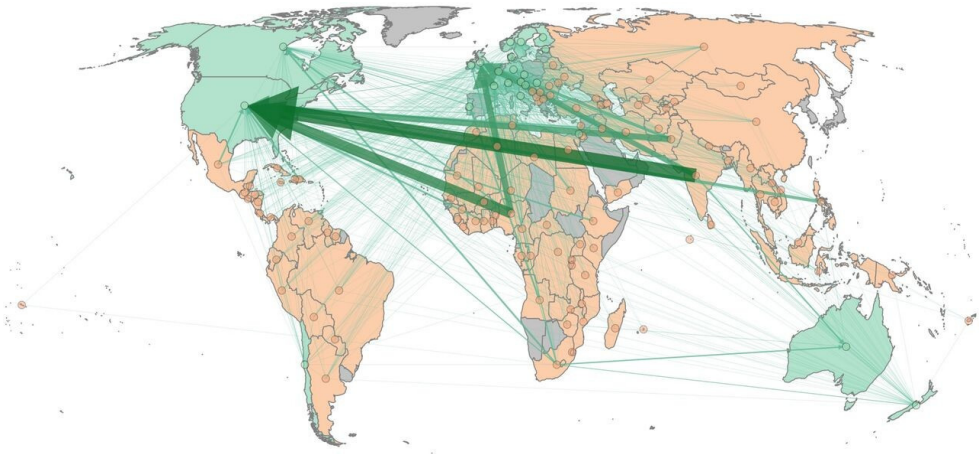


Figure 11. Physician migration patterns with arrows demonstrating the direction of migration. The arrow thickness is proportional to the cost of the associated physician migration to the source country. Adapted from Saluja *et al.*[163]

In 2010, in recognition of escalating "brain drain" with its detrimental effects upon the health systems in LMICs, the WHO Assembly adopted the WHO Global Code of Practice on the International Recruitment of Health Personnel (hereafter referred to as "The Code") in order to establish ethical principles and guidelines for the recruitment and migration of health workers between countries.[164] The Code recognizes that the migration of health workers can have significant consequences for both the source and the destination countries. Source countries may lose skilled health workers, which exacerbates staff shortages and hinders the delivery of essential services. Destination countries, on the other hand, benefit from the influx of skilled health workers who contribute to the health workforce imbalances. The World Health Assembly reaffirmed the centrality of The Code and urged member states to invite all relevant stakeholders to implement the recommendations of The Code in full. It also pointed out that the UHC service coverage index and health workforce density should be used in order to identify and support countries that face the most pressing UHC-related health workforce challenges.[138,139,165]

"Brain drain" most likely affects the delivery of surgical services in many LMICs, but there is a paucity of data analyzing and describing the migration of surgeons, anesthesiologists and obstetricians from LMICs to HICs in order to confirm this.[166]

Research QII: How are HICs dependent upon surgeons, anaesthesiologists and obstetricians from LMICs?

Research QIII: What is the estimated proportion of surgical specialists from LMICs who work currently in an HIC?

South Africa has been described previously as an exporter of well-trained physicians to HICs.[167–170], but it is also known as a recipient of physicians from sub-Saharan countries.[171–173]. Consequently, South Africa has been described as an African hub for physician migration.[174] A more detailed study on the migration of surgeons, anesthesiologists and obstetricians in and out of South Africa has not yet taken place.

Research QIV: What is the migration of surgical specialists in and out of South Africa and in proportion to the size of the total workforce?

Quality

Poor health outcomes are the result of many factors, including the nature and severity of disease, patient behavior, and structural elements of health systems. Work towards increasing patients' access to surgical care in LMICs, while maintaining the quality of surgical care, is paramount and requires a comprehensive approach that addresses various aspects of the health system.[175]

Task-shifting

In regions with a critical shortage of health workers, "task-sharing" or "task-shifting" is a potential solution to the need to strengthen the existing workforce, and increase patients' access to healthcare.[176] Many HICs and LMICs have a history of healthcare provision by other cadres, such as nurses, clinical officers, or mid-level providers, who are not trained as physicians, but who are capable of undertaking many of the diagnostic and clinical functions that need to be performed.[177,178] The term "task-shifting" implies the shifting of certain tasks from specialist personnel to health workers with less training and fewer qualifications, without supervision by a specialist physician, such as an associate clinician, Figure 12, or a general physician. In contrast to "task-shifting", "task-sharing" is when the above situation occurs, but the health worker is under the supervision of a formal educated physician.[179] Task-shifting in surgery, obstetrics, and anesthesia occurs throughout the world across all regions and income levels, but is skewed towards health workers in sub-Saharan Africa.[180]

Figure 12. Non-physician clinician in anesthetics supervising the measurement of vital parameters (pulse oximetry) during emergency surgical care at Masanga Hospital, Sierra Leone. Photo: Adam Lantz.

International clinical work

In some HICs, increasing surgical subspecialization, centralization and workforce profligacy have created a global inverse, where surgeons struggle with domestic case-volume shortages and seek ways to compensate for insufficient clinical exposure.[181,182] Their endeavor to gain more practical experience of relevant surgical cases may serve as an impetus for these surgeons to participate in international clinical work.[183] Such surgical visits most likely fulfill many aspirations, such as progressing personal development and altruism, while simultaneously certainly benefitting their own high-income health system when they return home as a more experienced surgeon with multifaceted surgical skills, Figure 13.[184–187]

Surgical missions

The shortage of suitably trained health workers in LMICs is bridged occasionally by visits from health workers in HICs in order to augment healthcare service capacity and address the critical burden of surgical disease. Humanitarian surgery has a long-standing tradition within global health, and the concept of "medical missions" dates back to the time of the early Christian church during the 16th and 18th centuries.[188] By the 19th century, Elijah Bridgman, a missionary from the USA, had highlighted the importance of surgeons in such missionary work. However, discussions began to arise regarding whether the provision of social service care or evangelism should be the main focus of such visits. During the colonial exploration, the aims of most medical missions were questioned. It was not until the need arose for volunteer medical organizations

during the First and Second World Wars in Europe that the focus changed to be on the patient, and not on religion and politics.[188] According to a review in 2016, there are at least 403 Non-Governmental Organizations (NGOs) performing surgery in LMICs.[189] Short-term surgical missions to such countries have been questioned as a result of insufficient follow-up, low cost-effectiveness, and lack of sustainability.[190–193] The impact of humanitarian surgery on surgical health systems, such as surgical volume, outcome and capacity-building in LMICs is still only reported fragmentally and has not been investigated fully.

Research QV: What are the experiences and perceptions of LMICs with regard to visiting surgical teams from an HIC?

There is a long-standing tradition in Sweden, as in many other HICs, of health workers participating in international clinical work in order to fill gaps in the shortage of health workers in LMICs, but their experiences have not yet been explored. How prepared are surgeons from HICs to undertake international clinical work in an LMIC? Can they speak the local language in order to communicate effectively with patients and health workers? Or understand the different culture or epidemiological context in that country?

Research QVI: What are the experiences, barriers and perceptions of international surgical work among Swedish orthopedic surgeons, anesthesiologists and obstetricians?

Figure 13. Donated supplies in a storage room at Masanga hospital, Sierra Leone. Unfortunately many of the donated supplies cannot be utilized as a result of the lack of storage, technology and staff with the right competencies. Photo: Adam Lantz.

Aims

The purpose of this thesis was to investigate and explore the current global surgical workforce, with a focus on access, migration and quality, plus an assessment of how HICs can mitigate the process of delivering surgical care in LMICs. The specific aims of the included studies are:

I. To quantify and analyze the global specialist surgical workforce and to build a WHO surgical workforce database through the use of a cross-sectional study design.

II. To calculate the dependency of HICs on recruiting surgeons, anesthesiologists and obstetricians from LMICs through the use of a cross-sectional study design.

III. To measure the proportion of surgeons, anesthesiologists and obstetricians from LMICs who are now working in an HIC through the use of a cross-sectional register-based study design.

IV. To quantify and analyze the surgical workforce in South Africa who were educated in another LMIC, and South African surgical specialists who have emigrated to an HIC, using a register-based study design.

V. To investigate how LMICs perceive short-term visits from surgeons, anesthesiologists and obstetricians trained in an HIC, by conducting a review of the literature.

VI. To investigate Swedish orthopedic surgeons', anesthesiologists' and obstetricians' experience of, interest in, barriers to, and perceived value of international clinical work, and whether there were any differences in their responses, based on gender, specialty and seniority using a cross-sectional survey study design.

Methods

A summary of the methods used in the six studies is shown in Table 3.

Table 3. Study design, source of data, subjects and sample size and primary outcome of the six studies.

Study	Study design	Source of data	Subjects and sample size	Primary outcome
I	Cross-sectional survey study	Survey and review of publicly available sources	167 countries (194 surveyed)	The global distribution of surgeons, obstetricians and anesthesiologists
II	Cross-sectional survey study	Survey and review of publicly available sources	14 HICs (75 surveyed)	HICs' dependency on surgeons, anesthesiologists and obstetricans from LMICs
III	Cross-sectional study	The WHO Health Observatory data repository and data from Study II	102 LMICs	The proportion of surgeons, anesthesiologists and obstetricians working abroad
IV	Cross-sectional study	The Health Professions Council of South Africa (HPCSA) and data from Study II	43,621 physicians in South Africa and 14 HICs	The proportion of foreign surgeons, anesthesiologists and obstetricians in South Africa, and the proportion of surgeons, anesthesiologists and obstetricians from South Africa working in HICs
V	Systematic review	Review of publicly available data sources	30 articles out of 3867 identified	LMICs' experience and perception of visiting surgical teams from HICs
VI	Cross-sectional survey study	Survey of all Swedish orthopedic surgeons, anesthesiologists and obstetricians	636 Swedish orthopedic surgeons, anesthesiologists and obstricians	Swedish orthopedic surgeons', anesthesiologists' and obstetricians' experience of, intrest in, barriers to and perceived value of international clinical work

Study design

Study I is a survey of all WHO member states and a systematic review of available sources in order to capture the number of surgeons, anesthesiologists and obstetricians working in those countries. Multiple imputation was used to estimate missing data from countries for which no data were available, in order to estimate the global number

of providers. Study II is a survey study of HICs' dependency upon surgeons, anesthesiologists and obstetricians from LMICs. Study III is a cross-sectional register-based study in which we combined data from the WHO Health Observatory data repository with data from 14 HICs on the country of the doctor's initial medical qualification in order to measure the migration of surgical specialists. Study IV is a retrospective cross-sectional observational study in which we combined data from the Health Professions Council of South Africa (HPCSA) with data from HICs on the number of surgeons, anesthesiologists and obstetricians, and their country of initial medical qualification, in order to measure surgical migration to and from South Africa. Study V is a systematic review, conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, of the perception of LMICs of visiting surgical teams from HICs. Study VI is a cross-sectional survey that was sent to all Swedish orthopedic surgeons, anesthesiologists and obstetricians, in order to assess their experience of, interest in, barriers to and perceived value of international surgical work.

Definitions

In all studies, we assumed that all surgeons, anesthesiologists and obstetricians were practicing actively, according to the local medical licensing authorities. Residents or trainees were excluded, so that only fully trained physicians were included in our studies, when this was possible. We also excluded visiting specialists from other countries on short-term visits whenever possible, to fully reflect the true numbers of surgeons, anesthesiologists and obstetricians working in that country. Physicians and other health providers who were not licensed as surgeons were excluded, even in countries where such providers may be permitted to perform certain operations. All surgical specialties were included in the surgeon category. Intensivists were excluded if they were registered separately from anesthesiologists. Non-obstetrician gynecologists were excluded if they were registered separately.

Dependency, in Study II, was defined as the percentage of physicians within the fields of surgery, anesthesiology and obstetrics, who had been awarded a medical degree from an LMIC. The same definition of foreign medical graduates was used in Studies III and IV. In addition, we used the previous definition of emigration factor, which was defined as the proportion of surgeons, anesthesiologists and obstetricians working abroad, according to Mullan.[154]

Studies I–IV used the WHO country names and regional classifications, along with the World Bank income classification (2014 revision, Figure 14), based on the *per capita* gross domestic product which was converted using the World Bank Atlas Method, Table 4.[194] The purpose of the World Bank Atlas Method is to reduce the

impact of exchange rate fluctuations on the cross-country comparisons of national incomes.[195]

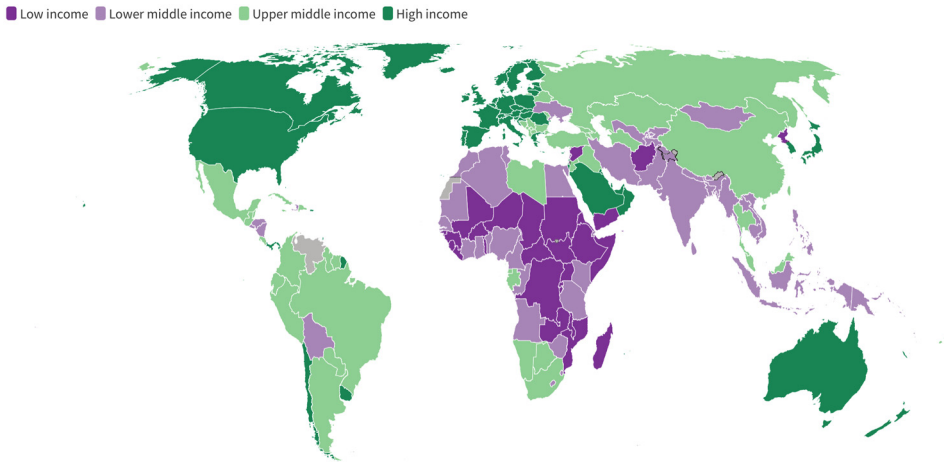


Figure 14. World map of World Bank income classification.[194]

Table 4. Thresholds of the World Bank income classification.[194]

Income definiton	Gross national income classficiation in dollars
High	>13,205
Upper-middle	13,205-4256
Lower-middle	4255-1086
Low	<1086

Data collection and data sources

Study I begun in 2014, with the collection of data through contacts with Ministries of Health, WHO individual country offices, professional societies, and members of the WHO's GIEESC. Publicly available data sources, including reports and publications, were used wherever no data could be obtained through direct contacts, or when contacts referred to such reports. Multiple follow-up emails and telephone calls were made during the study period. A total of 167 out of 194 countries with primary data were included in the analysis.

Study II was conducted during the same time period as Study I. An inquiry was sent to all HICs' Ministries of Health, requesting data on the number of surgical providers and their country of initial medical qualification. A total of 14 out of 75 HICs

responded to the inquiry. Multiple follow-up emails and telephone calls were made during the study period in the latter part of 2014.

Study III combined data from the WHO Health Observatory data repository with data on the country of initial medical qualification from 14 HICs. In total, data from 102 LMICs and 48 HICs were included in the study for analysis.

Study IV collected data in 2016 through the public database HPCSA (Health Professions Council of South Africa), and combined these data with those from 14 HICs on the country of initial medical qualification.

Study V was a systematic review that was conducted according to the PRISMA guidelines. We searched PubMed/Medline (the National Library of Medicine, Bethesda, USA), Embase (Elsevier), the Global Health database (EBSCO [Elton B. Stephens Company, Ipswich, USA[), Global Index Medicus (WHO) and controlled vocabulary terms (Medical Subject Headings [MeSH, the National Library of Medicine, Bethesda, USA], Emtree [Elsevier], and Global Health thesaurus terms) when available in January 2020, and re-ran the search in November 2021. Complementary manual searches were run in African Journals OnLine (AJOL) and Google Scholar. A total of 30 articles out of 3867 identified were included for analysis.

Study VI was conducted and data were collected during 2020 and the early part of 2021. The survey was designed and stored in REDCap (Research Electronic Data Capture, Vanderbilt, USA). The survey was validated before dissemination by an independent focus group of surgeons experienced in all aspects of surgical training. We sent the survey to a convenience sample of colleagues to assess readability and comprehensibility. Minor adjustments were then made before it was distributed to the Swedish Orthopaedic Association (SOF) in 2020, and to the Swedish Society for Anaesthesiology and Intensive Care Medicine (SFAI), and the Swedish Society of Obstetrics and Gynecology (SFOG) in early 2021. The survey contained questions on dependent dichotomous variables (experience of international clinical work), independent categorical variables (gender, medical specialty and seniority), and continuous variables (years between medical license and first international clinical trip, number of trips, longest trip in weeks, and median duration of stay in weeks). It also requested information on perceived barriers to international work, the destination country, and the perceived values of working abroad. A total of 636 out of 5776 orthopedic surgeons, anesthesiologists and obstetricians were included in the study for analysis.

Outcomes

Study I's primary outcome was the global distribution of surgeons, obstetricians and anesthesiologists. Study II's primary outcome was HICs' dependency upon surgeons, anesthesiologists, and obstetricians from LMICs. Study III's primary outcome was the proportion of surgeons, anesthesiologists and obstetricians working abroad. Study IV's primary outcome was the proportion of foreign surgeons, anesthesiologists and obstetricians working in South Africa, and the proportion of surgeons, anesthesiologists and obstetricians from South Africa now working in an HIC. Study V's primary outcome was LMICs' experience and perception of visiting surgical teams from HICs. Study VI's primary outcome was Swedish orthopedic surgeons', anesthesiologists' and obstetricians' experience of, interest in, barriers to, and perceived value of international clinical work.

Statistical analysis

Details of the variables covered and the statistical tests used are given in Table 5.

Table 5. Variables covered and statistical tests used in this thesis.

Study	Variables	Statistical tests
I	Numerical continuous (density)	Multiple imputation
II	Numerical discrete (proportion) Categorical nominal (WHO regions) Categorical ordinal (WBI group)	Kruskal-Wallis test of variance Mann-Whitney U test Univariate linear regression
III	Numerical discrete (proportion) Categorical nominal (WHO regions) Categorical ordinal (WBI group)	Kruskal-Wallis test of variance Mann-Whitney U test Univariate linear regression
IV	Numerical discrete (proportion) Categorical nominal (WHO regions) Categorical ordinal (WBI group)	Univariate linear regression
V	Numerical continuous (studies)	Thematic analysis Mann-Whitney U test
VI	Numerical continuous (respondents) Categorical nominal (sex, specialty) Categorical ordinal (medical seniority) Numerical continuous (trips)	Univariate linear regression Univariate logistic regression Multivariable logistic regression

WHO: World Health Organization; WBI: World Bank Income

Descriptive statistics

Descriptive statistics were used in all six studies to describe the distribution, measure of central tendency and variability of the data sets. Frequencies of numerical and categorical variables were reported with proportions. Distribution was assessed by plotting histograms, and calculating and interpreting skewness and kurtosis. Normal distribution was defined by the histogram being bell-shaped and symmetrical around the mean. If the histogram was difficult to interpret, skewness and kurtosis were used to determine whether the data were distributed normally. The mean was used for data distributed normally, and the median was used if data were not distributed normally. Variability was assessed by standard deviation (SD) or IQR. Data were presented with 95% CI.

Inferential statistics

Different inferential statistical tests were used to compare groups with different types and numbers of independent variables. The Kruskal-Wallis test of variance was used in Study III to compare non-normally distributed ordinal variables (WHO regions and World Bank income categories). The Mann-Whitney U test was used in Studies II and III to compare two groups (countries in workforce crisis versus all other countries).

The association between a dependent variable and one or more independent variables was assessed using regression models.[196] This approach was used in Studies II, III, IV and VI. Univariate linear regression was used if the dependent variable was continuous or ordinal, with one independent variable. Univariate logistic regression was used if the dependent variable was binary and with one independent variable. The results were presented either with ß or odds ratios (OR) with 95% CI. If the independent variable was associated significantly with the dependent variable ($p<0.05$), it was included in the multivariable logistic regression using a forward stepwise selection process with multiple independent variables. Adjusted dependent variables were presented with adjusted OR and 95% CI. Adjustments for multiple comparisons were considered in Study VI. All independent variables were considered to be clinically relevant.

Qualitative data

In Study V, we used a qualitative study design to extract, assimilate and structure information into themes in order to understand fully the meaning, experiences and LMICs' perspectives on visiting surgical teams from HICs. Qualitative research expands both the depth and breadth of knowledge into complex research questions compared to quantitative methods. However, it is important to bear in mind that there

is limited generalizability, potential researcher bias and subjectivity of the interpretation of the study results.[197]

Missing data

Missing data can reduce the statistical power and produce biased estimates, which can lead to invalid conclusions. Modeling approaches are invaluable methods to understand human health and disease; however, their results are only estimates, and concerns exist about their reliability, applicability and consistency.[198] The extent of missing data in this thesis was generally low. In Study I, a small number of countries did not provide any data. For those countries, a multiple imputation model was used to represent the density of surgical providers, based on 16 selected national indicators from the World Development Indicators data bank (the World Bank). A total of 100 imputations were made, restricted to absolute values. For all other studies, an assumption of MCAR (Missing Completely at Random) was made, and pairwise deletion was used when applicable (Study VI).

Software

Data were input into Microsoft Excel for MacOS (versions 2011 and 2016, Microsoft Corporation, Redmond, WA, USA), and analyzes were carried out in IBM® SPSS® versions 22 and 29 for MacOS (International Business Machines Corporation, Armonk, NY, USA). All tables and figures were created using Microsoft Excel and PowerPoint for MacOS (version 2016). Data were stored in REDCap. ReadCube Papers (Digital Science & Research Solutions, Inc., Cambridge, MA, USA) was used as the reference manager program.

Ethical considerations

All data in this thesis were aggregated and did not include any sensitive personal identifiers. The data from Study I are available publicly from the WHO. According to the Swedish Ethical Review Act (Act 2003:460: The Act Concerning the Ethical Review of Research Involving Humans),[199] The Swedish Ethical Review Authority cannot review research that is not undertaken in Sweden. However, three studies (Studies I, II and IV) were initiated in the USA and were approved by the Ethical Review Authority Board of Boston Children's Hospital[200] (Boston, MA, USA – IRBA00006049-4, IRB-P00006049, IRB-P00024135, respectively. For Study VI, we applied for and was granted ethical review, since formal approval is only possible for research actually handling sensitive personal identifiers, according to paragraph 3, by

The Swedish Ethical Review Authority (DNR 2020-07106). Studies III and V also did not require ethical approval.

However, because the Swedish legislation only permits data collection in Sweden and not globally, there are important ethical considerations that need to be considered when carrying out good research practices, and these should be accounted for when handling global data sets. They include data security, collaboration, sharing of data, and data transparency. In the pursuit of accurate, reliable and robust data, it must be remembered by all that someone is accountable for the collection, handling and transfer of the data. It is important that administrative tasks, including the burden of data gathering, do not have to compete with other important tasks. In order to minimize the administrative burden on resources that are already scarce, indicators with high impact should be prioritized, by using existing collecting channels, improving digital solutions, and outsourcing tasks to governments, academic departments, and visiting NGOs.

Results

Study I

Data on the number of surgeons, obstetricians and anesthesiologists were obtained from 167 out of 194 WHO member states, with 157 countries providing information on all three specialties. This corresponded to 92% of the global population and was representative across WHO regions, WBI categories and healthcare expenditure percentiles.

Based on the available data and imputation for those countries where no data were available (an additional 27 countries), the estimated number of surgeons was 1,112,727 (IQR: 1,059,158–1,177,912), anesthesiologists 550,134 (IQR: 529,008–572,916), and obstetricians was 483,357 (IQR: 456,093–517,638). LMICs represented 48% of the global population, but only had 20% of this surgical workforce.

There were significant differences found between the six WHO regions[201] in terms of surgical density. The African region had a median density of 4.4 surgeons per 100,000 population (IQR: 2.9–6.2), compared to 51 in the Americas (IQR: 50–52), 15.8 in the Eastern Mediterranean region (IQR: 14.3–18.1), 68.9 in the European region (IQR: 68.5–69.4), 6.7 in the South-East Asian region (IQR: 6.4–7.0) and 36.1 in the Western Pacific region (IQR: 35.4–37.1), Figure 15. In the quintile of countries with the highest health expenditure *per capita*, there were 63 surgeons, obstetricians and anesthesiologists per 100,000 people (IQR: 47–90), compared to 1 (IQR: 0.5–2) in the lowest quintile, Table 6.

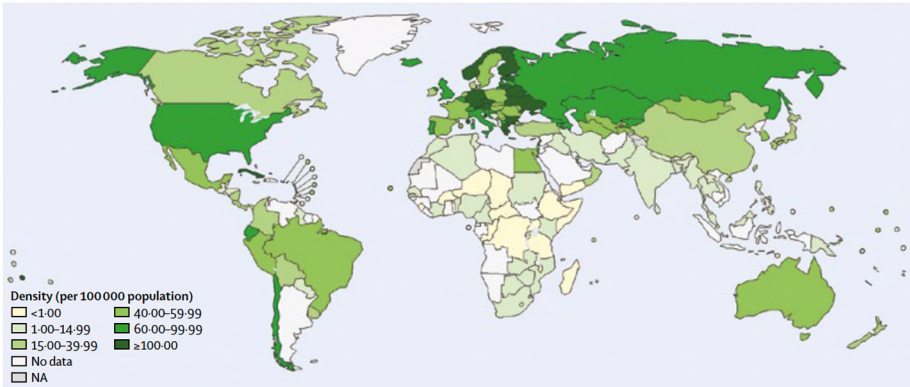


Figure 15. The global distribution of surgeons, anesthesiologists and obstetricians per 100,000 population.[202]

Table 6. The global distribution of surgeons, anesthesiologists and obstetricians stratified by World Bank Income Category, World Health Organization (WHO) region and health expenditure.

	Population		Surgical providers		
	n	%	n	IQR	%
Global	7054	100	2068	(2006–2147)	100
World Bank Income Category					
High	1267	18	777	(772–783)	38
Upper-middle	2435	35	938	(917–963)	45
Lower-middle	2522	36	308	(284–340)	15
Lower	830	12	45	(33–60)	2
WHO region					
Africa	904	13	65	(45–89)	3
Americas	958	14	486	(476–495)	24
Eastern Mediterranean	601	9	114	(101–130)	6
Europe	904	13	607	(607–607)	29
South-East Asia	1837	26	117	(111–123)	6
Western Pacific	1850	26	680	(666–703)	33
Health expenditure quintiles					
5th	1016	14	633	(633–633)	31
4th	895	13	411	(401–423)	20
3rd	1822	26	711	(698–726)	34
2nd	2223	32	246	(224–280)	12
1st	1060	15	52	(41–65)	3

Study II

Data on the numbers of surgeons, anesthesiologists and obstetricians, including their country of initial medical qualification, were received from 14 HICs, Table 7. The surgical workforce of 295,477 practitioners in these countries included 53,428 international medical graduates (18.1%), of whom 35,482 (66.4%) came from LMICs.

HICs' dependency on surgeons, anesthesiologists and obstetricians from LMICs was 12.0%, of whom the greatest proportion came from the South-East Asian (4.5%) and Eastern Mediterranean (2.8%) regions. Half (49.9%) of all surgeons, anesthesiologists and obstetricians who had migrated from an LMIC came from a country in workforce crisis. Characteristics of the emigrated surgical workforce from LMICs are shown in Figure 16. There was no statistically significant correlation between the proportion of the national surgical workforce who had emigrated from an LMIC and the gross national income *per capita* (R^2=0.081, p=0.72), or health expenditure *per capita* (R^2=0.0006, p=0.93) of the destination country.

Table 7. Total number of surgeons, anesthesiologists and obstetricians (Total) and working international medical graduates (N), and number of international medical graduates from low-income and middle-income countries (n).

Country	Total	N	n	%
Australia	7311	711	353	4.8
Austria	5868	346	102	1.7
Canada	12,417	2418	1383	11.1
Estonia	731	20	6	0.8
Finland	6060	286	39	0.6
Ireland	1331	254	235	17.7
Israel	4846	2181	655	13.5
New Zealand	1774	708	277	15.6
Norway	3663	1280	118	3.2
Slovakia	3098	301	24	0.8
Slovenia	1595	137	104	6.5
Sweden	5340	723	130	2.4
United Kingdom	40,195	14,552	11,615	28.9
United States	201,248	29,511	20,441	10.2
Total	295,477	53,428	35,482	12.0

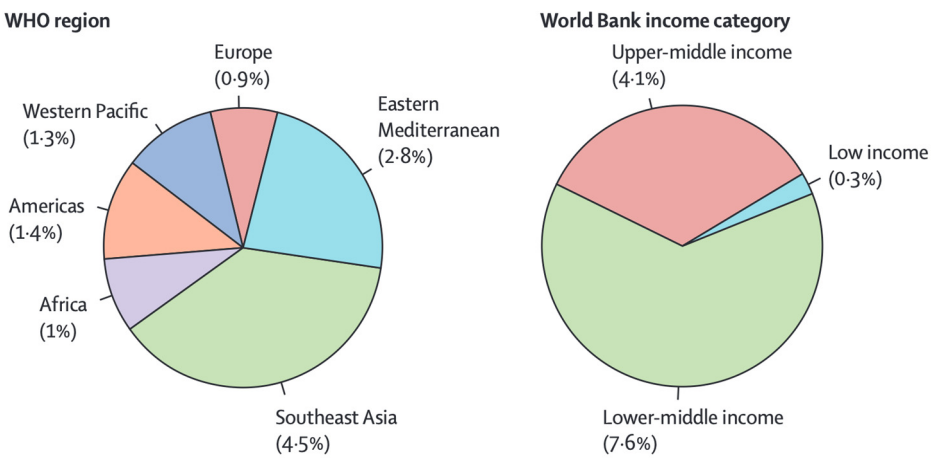


Figure 16. Mean dependency of high-income countries upon surgeons, anesthesiologists and obstetricians with a medical degree from a low-income or middle-income country, stratified by World Health Organization regions and World Bank income category.[203]

Study III

Included for analysis in this study were 102 LMICs and 48 HICs with complete data on the total number of surgeons, anesthesiologists and obstetricians. Of a total of 1,118,804 surgical specialists with a medical degree from an LMIC, 33,021 (3.0%) currently worked in the included 14 HICs. In low-income countries and lower-middle income countries the proportion of surgical specialists abroad was 6.0% and 11.0%, compared with 1.2% and 3.0% in upper-middle income countries and HICs, respectively. The countries most affected by emigration were Sri Lanka (61.1%), Sierra Leone (40.0%) and Jamaica (39.0%). In LMICs, the proportion of their surgical specialists now working abroad was, on average, 3.0%. The regions with the greatest proportion of their surgical specialists now working abroad were Africa (12.8%) and South-East Asia (12.1%), Figure 17. In particular, of all active anesthesiologists in the world who went to medical school in Africa, almost a quarter (23%) now worked in one of the 14 included HICs.

The proportion of specialists now working abroad, was not found to be greater for surgical specialists than for physicians and other medical specialists (p=0.465). In countries below the threshold of 14 surgeons per 100,000 people, or 20 surgical specialists per 100,000 people, a significantly higher proportion of specialists now worked abroad (11.6% versus 1.5%; p<0.001). When also including emigration from HICs, the proportion of surgical specialists now working abroad was found to be greatest in countries with the lowest surgical specialist density (R^2=0.043; p=0.011). There was no significant correlation between the proportion of surgical specialists now working abroad and the gross national income *per capita* (p=0.474), Figure 18, or health expenditure *per capita* (p=0.403).

Erratum:

In the published manuscript relating to Study III, (*Surgery* 2020; 168[Issue 3]: P550-557), in the Table of World Bank Income Category under European countries, the proportions of emigrated surgeons, anesthesiologists and obstetricians are accurate, but the income class is not in the correct order.

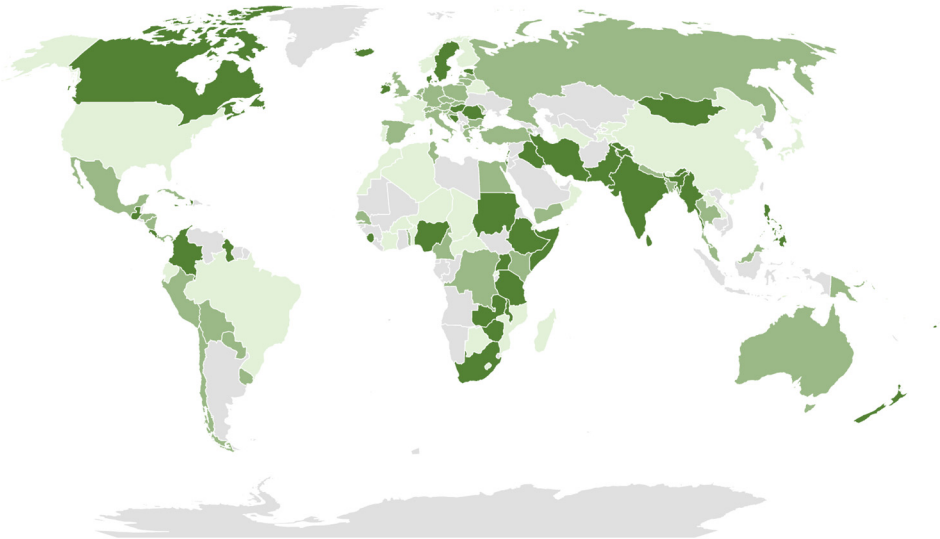


Figure 17. The proportion of surgical specialists now working abroad (percentage of surgical specialists working in high-income countries). Gray, N/A; light green <1%; medium green 1<5%; dark green >5%.

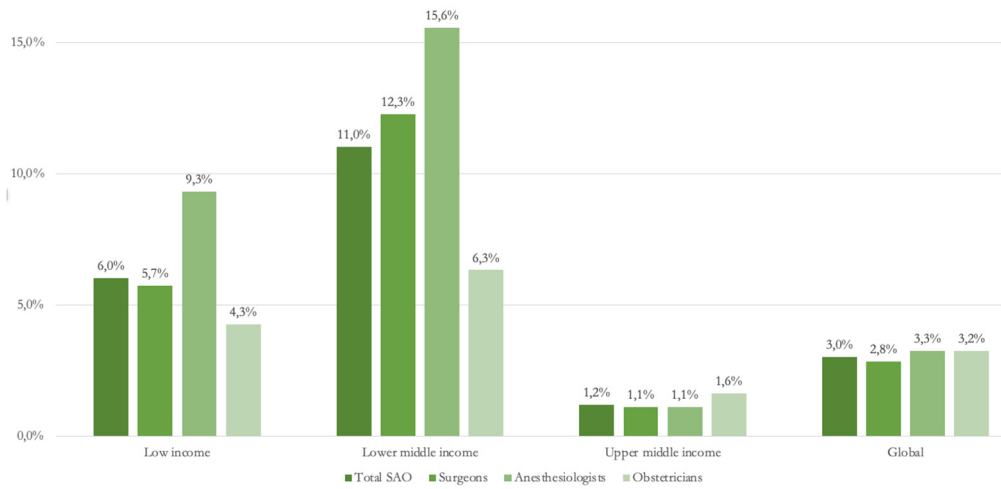


Figure 18. The proportion of surgical specialists now working abroad, stratified by World Bank Income categories and in total.[204]

Study IV

A total of 15% (6670/43,621) of all physicians in South Africa were surgeons, anesthesiologists and obstetricians (hereafter referred to as "surgical specialists"). The proportion who were surgeons was 55% (3685/6670), for anesthesiologists it was 26% (1749/6670), and for obstetricians 19% (1236/6670). Additionally, 1295 surgical specialists originating from South Africa were identified as working in one of the 14 included HICs. The specialist surgical density in South Africa was 12.1 per 100,000 population.

A total of 11.3% (713/6670) of all surgical specialists in South Africa were foreign medical graduates, of whom 56% (396/713) were from an LMIC, corresponding to a total of 5.9% (396/6670) of the total surgical specialists in South Africa, Figure 19. The South African dependency on foreign medical graduates from LMICs was lower for surgical specialists, compared to physicians in general (5.9% and 8.8%, respectively), and among surgical specialists, the dependency was highest for obstetricians (9.2%) and lowest for anesthesiologists (3.3%).

Low-income countries (LICs) had the highest proportion of surgical specialists who had emigrated to work abroad. More than 6% of the surgical specialists had emigrated to one of the included 14 HICs, and 2% had emigrated to South Africa. For some LICs, a particularly high proportion of their surgical specialists had emigrated to work abroad. When calculating the association, it was found that the fewer specialist surgical providers that a country had, or the lower the Gross National Income (GNI) *per capita*, the higher the proportion was of specialist surgical providers who had emigrated to South Africa, Figure 20.

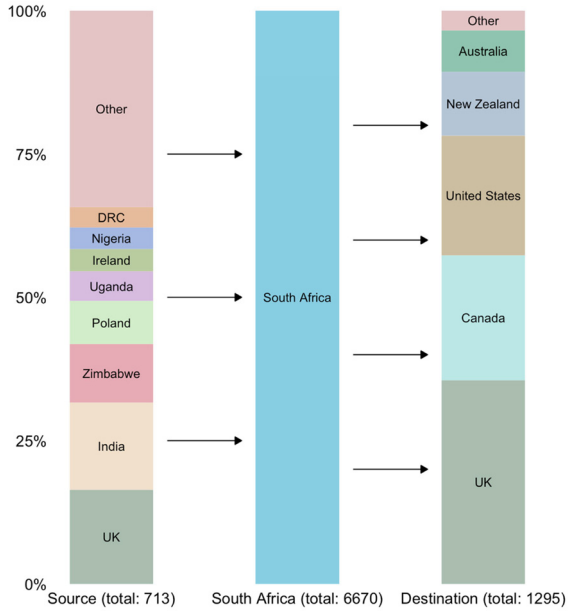


Figure 19. The leading source and destination countries for surgical specialists who have migrated in and out of South Africa.[205]

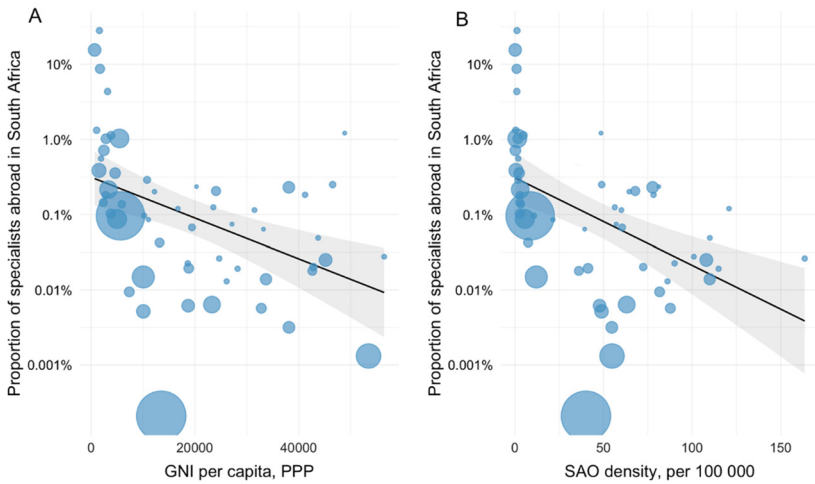


Figure 20. A: The correlation between the proportion of surgical specialists now working abroad in South Africa and gross national income *per capita*. B: The correlation between the proportion of surgical specialists now working abroad in South Africa and surgical specialist density per 100,000 population. Bubble sizes represent source country population size. GNI: Gross national income; PPP: purchasing power parity; SAO: surgeons, anesthesiologists and obstetricians.

Study V

Of 3867 studies identified, on the perceptions of LMICs of visiting surgical teams from HICs, 30 were included for detailed analysis, Figure 21. All studies were published between 2009 and 2021 with an increasing publication trend over time. A total of 77% (23/30) articles were first- and senior-authored by researchers from HICs, and 33% (10/30) were written without any involvement by researchers from LMICs.

Of the included articles, 83% (25/30) considered visits from surgical teams from HICs to be advantageous. The most commonly reported benefit to LMICs was skill transfer, which was cited in 53% of the studies (16/30). This included both learning about surgical techniques for advanced procedures, plus non-technical skills, including personal professionalism, decision-making and a positive cultural change. The second most commonly reported benefit was interest in a broader collaboration, cited in 33% of the studies (10/30). This included integration of educational efforts, such as didactic lectures, workshops and participation in surgical training in HICs. Help in alleviating the immediate need for surgical care, especially in marginalized communities, was expressed as a benefit in 27% (8/30) of the articles, and 20% (6/30) highlighted academic and career opportunities.

Many articles (73%; 22/30) described disadvantages arising from visits from surgical teams from HICs. The most commonly cited disadvantages were administrative burden and financial issues, such as poor schedules, lack of resources for planned surgeries and higher hospital bills as a result of increased number of patients. Further disadvantages were described as ethical and equity concerns, cited in 40% of articles (12/30), poor quality of care and postoperative complications, cited in 27% of articles (8/30), insufficient knowledge transfer, cited in 23% of articles (7/30), and communication barriers, cited in 23% of articles (7/30).

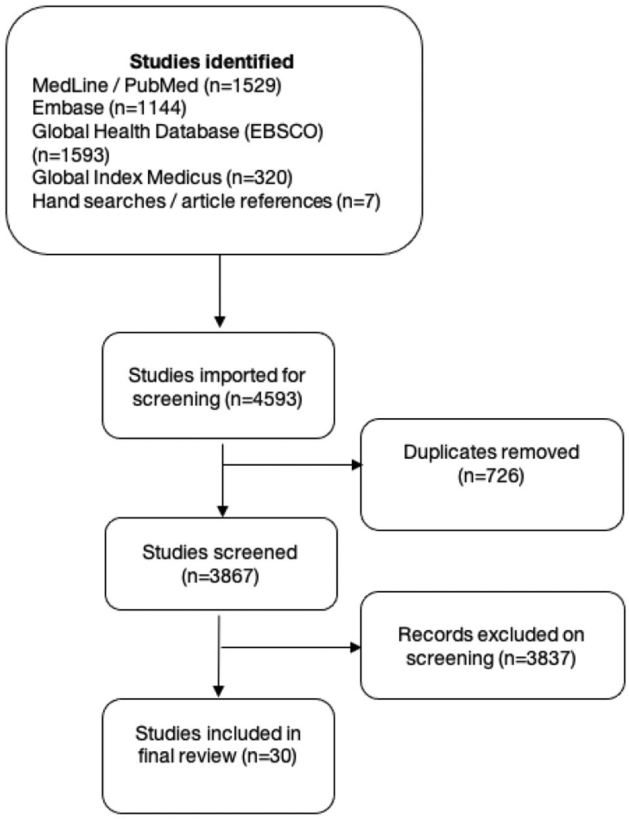


Figure 21. Flow chart illustrating the identification of studies in the systematic review of the perceptions of low-income and middle-income countries on visiting surgical teams from high-income countries. Of 3867 studies identified, 30 were included for detailed analysis.[206]

Study VI

The response rate to the cross-sectional survey sent to all Swedish orthopedic surgeons, anesthesiologists and obstetricians to assess their experience of, interest in, barriers to and perceived value of international clinical work was 11% (636/5776). The overall frequency of international clinical work carried out by these specialists was 45% (284/636), of whom 60% (169/284) had worked in an HIC and 40% (115/284) in an LMIC. Of those with no international clinical work experience to date, 69% (242/352) reported an interest in working abroad in the future.

Swedish orthopedic surgeons, anesthesiologists and obstetricians who had undertaken international clinical work in another HIC did so earlier in their medical career (a median of 7 years following qualification; IQR: 4–12 years; $p<0.001$) and did so more frequently (a median of 4 times; IQR: 1–15 times; $p<0.001$), but did not spend the longest time away (a median of 20 weeks; IQR: 2–52 weeks; $p=0.255$) or have a longer trip (a median of 2 weeks; IQR: 1–20; $p=0.083$), compared to Swedish orthopedic surgeons, anesthesiologists and obstetricians who had undertaken international clinical work in an LMIC.

International clinical work was overall more common among orthopedic surgeons (adjusted odds ratio [aOR]: 1.6; 95% CI: 1.0–2.6; $p=0.05$) and anesthesiologists (aOR: 2.0; 95% CI: 1.3–3.3; $p=0.003$) compared with obstetricians, and was more common among specialists (aOR 2.8; 95% CI: 1.5–5.1; $p<0.001$) and consultants (aOR: 7.0; 95% CI: 4.1–11.9; $p<0.001$) compared with residents, Figure 22. Overall, international clinical work was not associated with gender, but experience of working in an LMIC was relatively more common among men than women (aOR: 1.9; 95% CI: 1.0–3.4; $p=0.045$).

The most frequently reported barriers among Swedish orthopedic surgeons, anesthesiologists and obstetricians, with and without international clinical work, were family commitments at home, followed by difficulties in finding the right contacts, medico-legal challenges, and fear of not having the right competence ($p<0.001$). The most common perceived values of undertaking international clinical work in an LMIC were meaningfulness ($p<0.001$), helping patients in need ($p<0.001$), and experiencing other types of diseases ($p<0.001$), Figure 23.

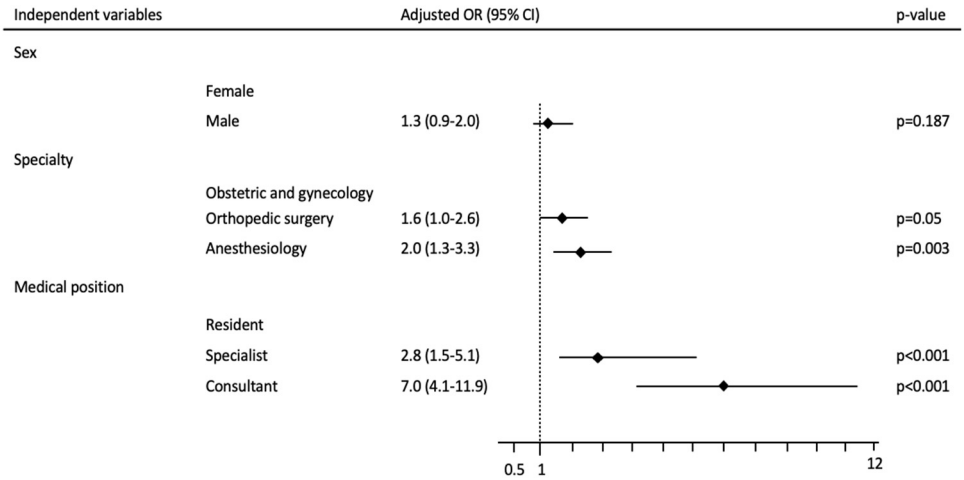


Figure 22. Adjusted independent predictors of having experience with international clinical work among 636 Swedish orthopedic surgeons, anesthesiologists and obstetricians. Multivariable logistic regression was used to calculate adjusted odds ratios (aOR) and 95% confidence intervals (error bars).

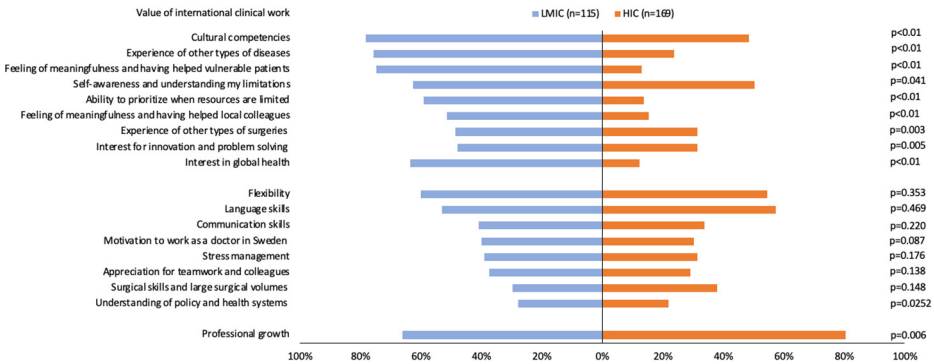


Figure 23. Population pyramid of Swedish orthopedic surgeons', anesthesiologists' and obstetricians' perceived value of international clinical work, stratified according to whether the work was undertaken in a low-income or middle-income country (LMIC), or a high-income country (HIC). Presented with column percentages. Univariate logistic regression was used to calculate p-values.

Discussion

Main findings

This thesis has explored and quantified the global surgical workforce with a focus on access, migration and quality through six research studies: (I) The lack of surgeons, anesthesiologists and obstetricians, particularly in the poorest countries, contributes to poor access to, and quality of, surgical care. (II) HICs are considerably dependent on surgical providers from LMICs and this deprives them of surgical capacity. (III) A considerable proportion of surgical specialists from LMICs work in HICs and this figure is greater for countries that have a lower surgical specialist density. (IV) South Africa acts as a regional hub for surgical specialists' migration, both from LMICs and to HICs. (V) Surgical short-term visits from HICs are insufficiently described from the perspective of stakeholders in LMICs. (VI) Swedish orthopedic surgeons, anesthesiologists and obstetricians working abroad have a high interest in international surgical work; however, their participation is limited by barriers preventing them from doing so.

Interpretation and impact

Access

Access to surgery is complex, and there are numerous interdependent factors that must align before patients can receive surgical care or undergo an operation. The results of this thesis explore access to surgical care mainly through two important aspects. First, we present the first compilation of the global distribution of surgeons, anesthesiologists and obstetricians, which could be translated to improving our understanding one aspect of access to surgery within different regions and countries. Second, we show the importance of recognizing and incorporating the concept of migration into future surgical workforce planning as it has a profound impact upon HICs and LMICs. Our results from Study I confirm that surgeons, anesthesiologists and obstetricians are scarce throughout the world and they are skewed unevenly towards HICs. The results resonate with the growing body of literature describing inadequate numbers of health workers across skill levels and specialties in many LMICs.[136] The surgical workforce crisis is particularly acute, and is especially severe because the global burden of surgical disease is growing.[33]

Expansion of the health workforce is therefore crucial. The rate of scaling up the number of health workers is quite low, but is estimated to be higher than that of the population growth.[207] Awareness, strategies and solutions are outlined in the WHO's publication: *Global Strategy on Human Resources for Health. Workforce 2030*.[134] These include workforce planning with proper supply-and-demand analysis by the individual country of its health workforce market in order to fill gaps, scale up training, provide education to broaden the health workforce, adhere to international guidelines on the international migration of health workers, and sustain and retain health workers through attractive employment options. In addition, the WHO has published an implementation guide in which it recommends the collection of representative data by adopting a united and systematic approach, in order to ensure reliability and comparability between countries and regions.[208]

The data on the specialist surgical workforce density have been updated twice since our first publication, and the densities are coherent with our results.[100,209] Based on our data from Study I, the LCoGS suggested two baseline threshold levels for the densities for surgeons, obstetricians and anesthesiologists. The two thresholds were derived by a triangulation based on maternal mortality, current surgical workforce rates and productivity, and were set to 20 and 40 surgeons, anesthesiologists and obstetricians per 100,000 population.[210] When adding in the worldwide median surgical productivity (number of procedures per surgeon or obstetrician), an estimated requirement of 5000 procedures per 100,000 people per year was calculated. Overall, in order to address the current need for 143 million surgical procedures annually, an additional 1.1–2.1 million surgeons, anesthesiologists and obstetricians will be required between now and 2030.[210–212] That is twice the current workforce. This is an impossible task to achieve with respect to the need to educate suitable personnel in the near future, despite the WHO investing in the health workforce.[213] More granular data on the number of anesthesiologists have been calculated, which estimated that a minimum number of four anesthesiologists per 100,000 population was needed.[214]

Several studies have been published in which the researchers collected data on and analyzed the six core indicators defined by the LCoGS on a national and subnational level for feasibility, validity and evaluation. These studies came from countries that included Colombia, Brazil, Uganda, Somalia, Pakistan and India.[215–220] Despite these countries' different socioeconomic status and background in healthcare, they all agreed that the limited and heterogenous data across regions need to be improved and collected routinely for comparability and future planning. In 2021, an Utstein consensus report was published in which the six core indicators were revised and updated. Davies *et al.* removed one of two financial risk protection indicators, and refined descriptions and defined the data points that were required in order to construct the five remaining indicators: geospatial access, workforce, surgical volume, perioperative mortality and

catastrophic expenditure. Using a uniform definition, they highlighted the next step, which was how to collect data on the indicators using in-country settings. They also advised how to use the digital infrastructure required for the collection of the data.[221] The surgical assessment tool that was recommended could prove useful in determining nationwide trends in data and indicators, and in assessing variability and granularity within countries.[222]

Achieving the changes that are necessary in order to increase access to surgical care and break through barriers will require a collaborative effort to address many aspects simultaneously. The first such change could be altering policy and integrating surgical, anesthetic and obstetric care into national surgical plans and nationally representative demographic and healthcare surveys.[223] Second, awareness could be increased through academia, global health, and international surgery communities. Third, health workers performing surgery must be well-defined and their numbers expanded through national healthcare agendas. Fourth, Ministries of Health, national governments and national surgical providers' associations should be proactive in setting goals for expanding surgical provider education. Fifth, HICs should adhere to immigration policies and balance their individual country's surgical needs with the consequences of health workers migrating to them from LMICs. Sixth, NGOs and other non-profit charitable organizations should consider adopting essential surgery as a healthcare priority in low-resource settings.[193] Finally, we desperately need to see a growing number of collaborations between different individual HICs, and facilitate training of surgeons, anesthesiologists and obstetricians in LMICs where senior colleagues are lacking. These efforts, supported by the WHO Global Initiative for Emergency and Essential Surgical Care, have shown promise in enhancing the quality of care available in LMICs, in addition to helping build up staffing capacity over the long term.[224]

Many of these interdependent factors were included in the LCoGS recommended NSAOPs, which were further ratified by the United Nations Institute for Training and Research (UNITAR) when it published an NSOAP manual to guide countries through the planning process.[91] Following the publication of the original LCoGS report in 2015,[47] many countries, including Nigeria, Ethiopia, Tanzania, Senegal, Rwanda and Zambia, have completed plans and expressed their commitment to implementation work.[225] However, the rate at which countries implement NSOAPs has decreased as a result of a lack of financial support, research capacity and local governance to coordinate the collective support of surgical health systems research in LMICs.[84,226,227] The feasibility of applying NSOAPs in health systems is still elusive without a proper fiscal space and evaluation of implementation plans.

Migration

The migration of surgeons, anesthesiologists and obstetricians can have a significant impact upon health systems, both in the source and the destination country. Many factors contribute to migration. "Push factors" refer to aspects that motivate or compel health workers, including surgical providers, to leave their home or source country and seek opportunities elsewhere, Panel 3. "Pull factors", on the other hand, are factors that attract and entice health workers to relocate to another country, region, or city, Panel 4.

Panel 3. Migration: push factors.

There are many push factors that mitigate migration including, for example, low salaries, inadequate financial incentives, limited career growth, lack of investment in health systems, political instability as a result of conflicts or war, lack of security, poor working conditions with heavy burden and low autonomy.

Panel 4. Migration: pull factors.

There are many pull factors that attract physicians and mitigate migration including, for example, better remuneration and working conditions, career development and research possibilities, political stability and security, increased recognition and reputation.

There is a paucity of studies on push and pull factors that contribute to the migration of surgeons, anesthesiologists and obstetricians. It seems that surgeons emigrate from LMICs to an HIC as a result of a lack of professional opportunities, poor infrastructure and limited specialist education.[166] This is in contrast to the migration of physicians, which has focused more on political, financial and security factors.[228–233] While surgical workforce migration may aggravate disparities in access to surgical care, it also offers important opportunities for collaboration and the gaining of experience and skills within foreign settings.

International exchanges can provide surgical providers with professional development, education and research possibilities. There is also a potential benefit for HICs in recruiting expatriate surgeons, anesthesiologists and obstetricians from LMICs, which could be used further in horizontal health system strengthening in source countries. Expanding professional societies, such as the College of Surgeons of East, Central and Southern Africa (COSECSA), have shown good retention rates

within the region, even though most surgeons are located in urban cities.[234,235] Surgical mentorships could be introduced that could increase knowledge, confidence and satisfaction in order to create a better working place.[236] There needs to be a well-considered distribution of national surgical services, with adequate referrals, in order to use the limited resources optimally.[237–239] Hospitals need to be helped to increase their preparedness for external shocks in order to prevent growing backlogs.[240] Investments and fiscal space in surgical health systems need to be increased in order to reduce the overwhelming burden on existing health workers. Finally, in order to ensure adequate numbers of specialist surgical providers, all countries should strive to adhere to international codes on recruitment of health workers and to assure adequate incentives for effective retention and equitable distribution of the global surgical workforce.[164]

It is well known that in HICs, physicians tend to stay where they train.[241] Which means that if we want physicians to practice in rural areas, and prevent their maldistribution towards urban cities, multidimensional incentives are required to encourage physicians to work in rural areas.[242]

Quality

Access to quality surgical care remains a critical issue for people living in LMICs. It is estimated that 23 million DALYs are lost each year as a result of in-hospital adverse events alone, and that two-thirds of these events occur in people living in LMICs.[243] With advocacy to improve access to surgical care, there will be a concomitant increase in the number of adverse events, resulting in needless disability and premature death. Expansion of surgical services to address the unmet need of surgical care would increase the total number of global deaths to 6.1 million people annually, of which 1.9 million deaths would occur in people living in LMICs.[107] To avoid this, the scale-up of access to surgical care must include quality improvement, but the definition of quality has been notoriously difficult to define and measure.[244]

Several quality health improvement programs and quality metrics have been developed, mainly within HIC settings.[245–247] Only a few studies exist on the quality of surgical care from the perspective of LMICs.[248] More common are studies on patient outcome, such as surgical site infections (SSI), which form the most frequent postoperative complication in all countries, and are associated with increased morbidity and mortality.[249,250] A set of 15 evidence-based indicators have been proposed in order to capture and measure the quality of surgical care in low-resource settings.[251] These have proved to be useful and have been demonstrated to be feasible in a low-income setting.[252] However, with the insufficient pursuit to recruit surgical providers with broad skills that could mitigate the shortage of local surgical providers, the implementation of task-shifting is increasing.

Surgical task-shifting exists, for example, in Mozambique, Tanzania, Malawi and Sierra Leone, where non-physician clinicians perform a range of different surgical procedures from acute surgical and obstetric care to chronic conditions.[253–258] Studies have shown no difference in patient outcome after a Cesarean section or inguinal hernia repair performed by a physician- or non-physician clinician.[259,260] Ensuring quality of surgical care remains a critical consideration when implementing task-shifting, and it is crucial to strike a balance between expanding access to surgery while maintaining high standards of care. The trend towards delegating the performance of surgical procedures to less educated health workers has clearly been met with resistance.[261,262] Arguments against such a move include the fact that surgical care involves more than just practical skills in the operating room, encompassing other important aspects, such as clinical assessment and examination in order to select the right patient for surgery, and the identification of patients who need referral for advanced treatment in a tertiary setting. In addition, non-physician clinicians have insufficient outlined boundaries in their scope of practice, education, supervision, available mentors and resources in order to provide adequate surgical care.[263]

Our results from Study V show that the disadvantages of surgical teams from HICs visiting an LMIC to work were consistent with those cited in the previous literature.[264] They include a lack of follow-up, meaning that local surgeons have to pick up the pieces by dealing with complications and performing corrective surgeries. Furthermore, they have to increase their surgical volume for the purposes of publicity, training and broader clinical experience.[265–268] The perceived advantages of visiting surgical teams from HICs to an LMIC were gaining advanced clinical skills, and improved professional development and bilateral collaboration.[269–272] The heterogeneity and subsequently lack of LMICs' perspectives indicate that there is no clear one way for surgical teams visiting an LMIC from an HIC to approach and aid clinical work in the LMIC. In response to previously described obstacles and in order to improve the quality of surgical missions in LMICs, there are established ethical guidelines to adhere to when surgical teams visit from an HIC, Table 8.[273,274]

Table 8. Recommendations in the guidelines for surgical providers on establishing projects in an LMIC. Adapted from Grimes *et al.*[274]

Recommendation	Description
Identifying partners	Individuals seeking placements should identify appropriate placements that match their skill set using existing programs.
Understanding local needs and resources	The trip must be responsive to local needs. There must be adequate contact prior to the trip between the visiting team and the local medical staff. Identify the local resources available, especially for postoperative care, such as the availability of blood transfusions, colostomy bags, laboratory facilities, radiological services, diathermy, plus type of anesthesia available, especially in rural areas. Avoid using complex technology in rural settings to ensure sustainability.
Training of local health providers and ensuring sustainability	A significant proportion of any trip should focus on training local health providers. There should be time set aside to train these staff in patient selection, pre-operative care, the operative technique, post-operative care and monitoring, together with the recognition and management of complications. There is a need to ensure training of other medical staff involved in patient care. Consideration should be given as to whether the proposed team embarking on the trip should be multidisciplinary.
Use of appropriate technologies and skills	Focus on training in basic surgical skills, basic trauma skills and perioperative management. Avoid complex procedures in rural areas. Consider designing postoperative protocols using local resources. Surgical trainees accompanying such trips should be able to teach and train or be supervised adequately. The training of local healthcaee providers should take priority.
Monitoring the quality of surgery	Outcomes must be monitored. Ideally these should not just be clinical but should involve measures of quality of life.
Management of postoperative complications	The local health providers should be taught to recognize and manage such complications and left with resources to treat complications adequately.
Costs	Consideration for the financial impact on the host institution should be taken into account and all efforts should be tmade to remove this burden, in order to maintain sustainability.
Sustainability	There should be regular trips made to the same institution over a period of a number of years in order to ensure capacity building and sustainability. Surgeons should make an effort to understand and interact with local communities and local medical staff in order to gain a better cultural understanding, enhance relationships and develop a true awareness of local need.
Working with local and regional training programs	Surgical initiatives should work in conjunction with, and in support of, local and regional training programs.

Despite the fact that brief surgical missions by doctors from an HIC to an LMIC are described insufficiently from the perspective of the latter's stakeholders, it is also important to investigate doctors in HICs' experience of, interest in, barriers to, and perceived value placed on international surgical work. We found that Swedish orthopedic surgeons, anesthesiologists and obstetricians seem to have a broad experience of, and interest in, international clinical work in LMICs, but that personal

and institutional barriers prevent them from pursuing such work. Further potentially stimulating international clinical work for HIC surgical providers includes international rotations during surgical training or while training in medical school.[275,276]

Telemedicine can play a valuable and useful role when conducted between HICs and LMICs with the right prerequisites, and it can increase both the access and quality of surgical care.[277] Telemedicine could facilitate remote preoperative assessments, clinical consultations, and address postoperative concerns, such as wound healing, drug management, rehabilitation, education and training.[277–280] E-learning is also a promising option for high-quality surgical training of health workers in LMICs.[281] Addressing both LMICs' perspectives and HICs' perceived barriers to international surgical work could enable synergies for sustainable partnerships between health workers in HICs and LMICs.

Limitations

The first part in this Discussion section describes the overall study limitations, with a focus on missing data and data uncertainty. The following part will discuss the strengths and weaknesses of each of the included Studies I–VI.

Bias

Bias can cause both over- and underestimation of the effect of an exposure on an outcome. Therefore, adequate identification of sources of bias is crucial when trying to mitigate its skewing effects, as well as when assessing observed relationships. A confounder is a variable that exerts an effect both on the exposure (independent) and outcome (dependent) data item. Most of the included studies in this thesis are retrospective cross-sectional observational studies, even though there are examples of longitudinal follow up. The types of biases applicable to this thesis and included studies are listed in Table 9.

Table 9. Applicable biases in this thesis.

Bias	Definition	Studies
Selection bias	The selection of study participants is not representative of the study population.	I, II, III, IV, VI
Reporting bias	Data are not reported as a result of ethical, cultural, or other beliefs.	II, VI
Publication bias	Some study results may not be published, for example, negative, disturbing or ethical results.	I, II, V
Academic bias	Researchers' own agenda and beliefs influence the interpretation of results.	My own interpretation of the results may be influenced by as a surgeon.

Missing data

Research in LMICs is challenging. Health systems are already on the limit of their capacity and are not designed for easy data access. There are no digital solutions, a poor infrastructure and difficulty in following up patients in order to evaluate outcomes.[282] Therefore, many studies produce data that are not reliable, or comparable to those of other settings because the conditions under which they are conducted differ so widely. However, taking missing data into account is essential in order to follow established guidelines and best practices and obtain accurate conclusions. In our studies, we handled missing data differently. In Study I, we used multiple imputation for data from a few missing countries where we had other parameters to use for imputation. In Studies II, III and IV, we used list-wise deletion of all countries with no data. In Study VI, we used pair-wise deletion with the assumption that data were MCAR, in order to avoid loss of power in analysis.

Data uncertainty

No sophisticated, or mathematically advanced statistical models were used in the studies; however, describing and addressing data uncertainty in statistics is crucial in order to achieve transparency and reliability of the analysis. In addition, it is important in order to be able to understand the limitations of the results, and draw informed decisions based on the information available to policy makers. Therefore, the results in this thesis should not be interpreted as a precise prediction nor planning target, but rather they highlight the magnitude of future challenges that need to be addressed. When handling large data sets from many different sources, such as in Studies I, II, III and IV, different definitions have to be used. For example, some countries classify specialties and subspecialties completely differently compared to other countries. This can lead to measurement error, potential bias, and inaccuracies as a result of self-reported data. I have addressed and quantified statistical uncertainty by calculating CIs based around the model estimates. CIs provide a range of values, within which the true parameter is likely to fall with a certain level of confidence. In Studies IV and VI, we used a CI of 95% to assess the reliability of the model.

Where data were not available, such as in Study II, in which a few countries could not provide data on the number of surgeons, anesthesiologists and obstetricians, global health estimates were devised to fill the gaps. However, this approach is not without losing certainty in results. Our model in Study I was based on 16 different national indicators collected and presented by the World Bank. After 100 imputations, results were skewed, and summary estimates were therefore presented with medians and interquartile ranges. In order to obtain more reliable results, collecting data from missing countries is, of course, essential.

Strengths and weaknesses

The strengths of this thesis lie in what it shows. The surgical specialist workforce is critically inadequate in many parts of the world, and grossly distributed inequitably in favor of HICs. HICs are highly dependent on specialist surgical providers with a medical degree from an LMIC. Countries with the lowest density of specialist surgical providers are affected most frequently by surgical workforce migration. South Africa acts as a regional hub for the migration of surgical specialists, both from another LMIC, and to an HIC. Short-term surgical visits by healthcare specialists from HICs are described insufficiently from the perspective of stakeholders in LMICs. Swedish doctors operating abroad have a high interest in undertaking international surgical work; however, their participation is limited by barriers that prevent them from pursuing such work.

To accelerate the process of scaling up of the surgical workforce, surgical density has become an incorporated measure into the WHO's Coverage of Essential Health Services (SDG 3.8.1),[140] which aims to "ensure healthy lives and promote well-being for all at all ages", and Target 8: "Achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all". Also it is included in the World Bank's DataBank: World Development Indicators,[283] the WHO's publication: *Global Reference List of 100 Core Health Indicators*[284] *(plus health-related SDGs)* and the WHO's publication: *National Health Workforce Accounts: A Handbook*,[285] which aim to collect the indicators more systematically.[286] Specialist surgical workforce density has also been used as a means of predicting neonatal and childhood mortality.[287]

There are some limitations in all six studies that must be considered. First, in Study I, data are lacking from 37 countries (although they are complete from 30 countries), which we have included with the imputed data. Second, some countries define surgeons, anesthesiologists and obstetricians differently to other countries, and include different sub-specialties. This makes it difficult to compare data from countries with different methodologies and included specialties. Third, we did not capture all healthcare specialists performing surgery, for example, residents, other physicians without a formal qualification in surgery, anesthesia or obstetrics, non-physicians or surgeons visiting from other countries. Fourth, with our methodology, we did not capture the national distribution of surgical providers or surgical services, between regions, urban or rural practices, nor private or public, which is also important when analyzing the availability of the workforce.[237,238] Fifth, we did not capture health workforce characteristics, such as gender, age, training, or performance.[288,289] Sixth, it is possible that not all captured surgeons, anesthesiologists or obstetricians were actively

working and available to healthcare services. Finally, our data were an observational snapshot of the current year in which the study was performed, and did not capture trends in the exit or entry of the workforce market. However, a study from 2016 with updated data did not find any significant difference in the total numbers of surgical providers between these data sets.[100]

Studies II, III and IV had similar limitations that must be considered when interpreting the results. First, data from HICs came from a survey study with a less than 20% response rate, and the included number of surgeons, anesthesiologists and obstetricians was fewer than 14% (295,000/2,100,000) of their global distribution. Therefore, the results represent only included HICs (14 countries) and may not reflect the situation in all HICs. Also, the design of our study did not allow us to determine whether surgeons, anesthesiologists and obstetricians had migrated before, during, or after specialty training, and we did not capture the internal attrition to ministerial positions or NGOs, nor the migration within and between other LMICs. Conversely, we also do not know to what extent specialists occasionally return to their country of origin or change occupancy, although anecdotally we know that this occurs.

In Study IV, the limitations are the same as in Studies II and III. We used the HPCSA database in order to collect data on the specialty and country of the doctor's initial medical qualification. However, we do not know whether all registered doctors were actively working.

In Study V, the most important limitation, from a methodological point of view, was the lack of formal assessment of potential bias. Evidently, some of the included articles were viewpoints, research letters and had small sample sizes, and obviously lacked robust methodology, which must be considered in the conclusions. Furthermore, Study V was conducted from an HIC, with a focus on the perceptions of LMICs, and even though some of the co-authors were working in an LMIC, the represented qualitative material might have been viewed from another perspective if all the co-authors had been from an LMIC. In Study V, when describing the quality of surgical missions by visiting teams from HICs who work in an LMIC, the term "quality", which has been described in the section *Global surgery metrics* (see page 34) must be distinguished from its more formal meaning of health outcome rather than opinions.

In Study VI, there was a very low response rate, which could implicate bias, as mentioned above. To encourage recipients to complete the survey, we could have used tailored incentives, for example complementary gift cards, t-shirts, or an invitation to an event. It would be very interesting to have gained some insight into those doctors who did not answer the survey. Do they have the same demographics? How would the results have changed if we could have included their input?

Future directions

Today, many patients in the world die or suffer from surgically treatable conditions that we could cure if only the finances and healthcare infrastructure were there. The future path to improving access, capacity and timely surgical care when needed is multifold. It includes a viable approach to promote sustainable solutions within surgical health systems by strengthening research and political advocacy and priority.

The dearth of surgical providers is acute. Besides long-term investment, advocacy and political priority, short-term feasible solutions exist. First, surgical task-shifting is cost-effective and feasible to implement in cases where there are no physicians. HICs could mitigate the need for skilled tutors and mentors in the training of local surgical providers if they are prepared adequately and can find a surrogate supervisor with local expertise and knowledge. This could help reduce the burden of surgical disease in the short-term, as well as building capacity for the future.

Second, local health workers need to be involved and encouraged to engage and collaborate in research. Health metrics can be instrumental in promoting surgical care. Practical, feasible, valid and easily collectible health indicators in LMICs are crucial, and could be used for priority setting and advocacy for increased investments. Scientific publications emanating from doctors working in an LMIC have increased dramatically in recent years, including studies on utilization and exploring indicators to access, and improve the capacity, timeliness, financial costs and quality of surgical care.[290] Most of these authors are affiliated to an LMIC, which must be seen as a strength in the research community, and should be encouraged further by HICs in order to avoid misconceptions and accusations of colonialism or safari research.[291–294] Future surgeons, anesthesiologists and obstetricians could be further engaged and encouraged to build the foundation that is necessary for the long-term provision of surgical care.[295–297]

Third, the long-term solutions proposed for tackling the unmet global need for surgical care require that attention is paid to national and local challenges that prevent the sustainable development of health systems. Existing and emerging epidemiology must be translated into action through tailored NSOAPs with adequate fiscal space and political priority.

Conclusions

I. There are two million specialist surgeons, anesthesiologists and obstetricians worldwide. LICs have 0.7 such providers per 100,000 population (IQR: 0.5–1.9), compared with 56.9 (IQR: 32.0–85.3) in HICs. The lack of surgeons, anesthesiologists and obstetricians, particularly in the poorest countries, contributes to poor access and quality of surgical care.

II. HICs' dependency on surgeons, anesthesiologists and obstetricians with a medical degree from an LMIC was found to be 12%. Half of all surgeons, anesthesiologists and obstetricians who had migrated from an LMIC came from a country in workforce crisis. HICs are significantly dependent on surgeons, anesthesiologists and obstetricians from LMICs, and this deprives the latter of surgical capacity.

III. A substantial proportion of all surgeons, anesthesiologists and obstetricians from low-income and lower middle-income countries currently worked in one of the studied HICs (6.0% and 11.0%, respectively). The proportion of surgical specialists from an LMIC who now work in an HIC is greater for countries with lower surgical specialist density.

IV. Of all surgical specialists currently working in South Africa, 6% were educated in another LMIC. At least 16% of South African surgical specialists had migrated to an HIC. South Africa is a regional hub for surgical specialists' migration, both from another LMIC, and to an HIC.

V. Surgical short-term visits from HICs are described insufficiently from the perspective of stakeholders in LMICs. Visiting surgical teams from an HIC to an LMIC should consider local needs and opinions before planning the trip.

VI. Swedish doctors have a broad experience and interest in operating abroad, with differences based upon gender, specialty and seniority. Multiple personal and institutional benefits of working abroad were reported, with significant differences found between Swedish doctors working in an LMIC or another HIC. Participation is limited primarily by family commitments at home, followed by difficulties in finding the right contacts, medico-legal challenges, and fear of not having the right competence.

Populärvetenskaplig sammanfattning

Hela fem miljarder människor av världens befolkning saknar idag tillgång till akut och säker kirurgi när det behövs. Den största andelen av dessa människor bor i fattiga länder i Afrika och Sydostasien där kirurgiska sjukdomsbördan är som störst. Endast en bråkdel av alla 300 miljoner operationer som görs årligen i världen genomfördes i dessa områden. Skadade eller sjuka patienter som ändå lyckas ta sig till sjukhuset och blir erbjuden kirurgisk behandling, för att inte dö eller få betydande kvarstående funktionsnedsättning, hamnar i stor ekonomisk skuld då det saknas sociala skyddsnät. En del patienter hamnar i fattigdom på grund av den stora ekonomiska bördan alla kostnader av transport, behandling och efterföljande rehabilitering innebär.

Det föreligger många anledningar till att så många personer i världen inte har tillgång till en operation när de behöver den som mest. Dels kan det vara svårt får många människor att upptäcka att det föreligger en anledning att söka sjukvård. Det kan till exempel vara enkla infektioner som leder till svåra sjukdomstillstånd på grund att man väntar hemma för länge. Om man väl kan ta sig till ett närliggande sjukhus måste det också finnas utbildad personal och rätt material för att kunna hjälpa till. Det kanske inte finns någon som kan behandla en infektion i ett knä? Eller ett brutet lårben på ett barn som ramlat ned från ett träd? För att sjukhus skall kunna utföra rätt behandling så behövs många olika resurser: rätt lokaler med rena instrument, personal som kan utföra operationen samt söva och smärtlindra, men också följa upp behandlingen och rehabiliteringen. Det är fortfarande många kvinnor som löper stor risk för komplikationer i samband med graviditet och förlossning för det saknas rätt utrusning och material.

Inom folkhälsa har kirurgi länge ansetts vara för dyrt, onödigt och komplicerat, framför allt i jämförelse med vaccinationsprogram eller infektionssjukdomarna som tuberkulos, HIV eller malaria. Behovet av kirurgi har på senare år ändrats då befolkningen överlever till större del sin uppväxt, får ökad ekonomisk tillgång och lever allt längre. Det innebär att många sjukdomar som diabetes, hjärtkärlsjukdom eller cancer ökar i befolkningen. Många av dessa sjukdomar kan man behandla med mediciner, men kräver också till stor del kirurgi. Kirurgi är bevisat vara mycket kostnadseffektivt.

Det behövs ytterligare ca 150 miljoner operation årligen, mestadels i den fattigaste delen av världen, för att personer skall undvika att lida av bestående funktionsnedsättning eller drabbas av för tidig död. En av anledningarna den ojämlika tillgången till kirurgi i världen är bristen och snedfördelningen på specialiserad

sjukvårdspersonal: kirurger, narkosläkare (anestesi) och förlossningsläkare (obstetrik). Läkarutbildningarna är ofta eftersatta i fattiga länder och är inte uppbyggda efter befolknings behov, eller för att möta den ökande efterfrågan på kirurgi. Många färdigutbildade läkare flyttar också till rikare länder eller mer befolkningstäta områden i storstäderna för få bättre ekonomiska möjligheter, chans att utveckla de kliniska färdigheterna, vidareutbildas eller påbörja forskning. Rikare länder kan hjälpa utsatta områden och länder där behovet av kirurgi är som störst. Det kan tillexempel vara att öka tillgängligheten av kirurgisk sjukvårdpersonal genom att inte aktivt rekrytera läkare från fattigare länder, men också genom att starta och underhålla långvariga och bestående kliniska- och forskningssamarbeten.

Avhandlingen består av sex (I-VI) studier. Dessa studier skall undersöka hur stor tillgången till kirurger, narkosläkare och förlossningsläkare ser ut i världen. Hur kirurger, narkosläkare och förlossningsläkare flyttar från fattiga till rika länder, samt hur stor andel av fattiga länders kirurger, narkosläkare och förlossningsläkare flyttar därifrån. Vidare undersöker vi hur sjukvårdspersonal i fattiga länder upplever tillfällig kirurgisk hjälp från rika länder och vilka faktorer som påverkar ortopediska kirurger, narkosläkare och förlossningsläkare i rika länder att arbeta utomlands.

Studie I handlar om tillgången till kirurgisk vårdpersonal i världen. Här har vi tillsammans med internationella organisationer kartlagt hur många kirurger, narkosläkare och förlossningsläkare det finns i varje land i världen. Med information från 167 länder, av totalt 194 länder, kunde vi konstatera att det finns cirka 2 miljoner kirurger, narkosläkare och förlossningsläkare. Dessa är dock inte jämnt fördelade mellan länder, befolkningsmängd eller sjukdomsbörda, utan majoriteten arbetar i den rikare delen av världen där sjukdomsbördan är som lägst.

Studie II handlar om hur höginkomstländer är beroende av kirurger, narkosläkare och förlossningsläkare från fattigare länder. Här har vi studerat 14 höginkomstländer, inkluderande USA, England, Irland och Sverige. Av alla kirurger, narkosläkare och förlossningsläkare i dessa 14 länder, har över en tiondel sin läkarexamen från ett fattigt land.

Studie III handlar om hur fattiga länder drabbas av att många läkare flyttar till rikare länder. Det har vi studerat genom att analysera hur stor andel av alla kirurger, narkosläkare och förlossningsläkare som arbetar i ett höginkomstland. Det har visat sig att många länder drabbas väldigt hårt av att läkare flyttar därifrån, framför allt länder med redan låg tillgång till kirurger, narkosläkare och förlossningsläkare.

Studie IV handlar om hur kirurger, narkosläkare och förlossningsläkare flyttar till och ifrån Sydafrika. Det visade sig att en ganska liten andel av kirurgerna, narkosläkarna och förlossningsläkarna i Sydafrika kom från ett fattigt land, det var betydligt större andel kirurger, narkosläkare och förlossningsläkare från Sydafrika som arbetade i ett rikt land. Sydafrika är ett strategiskt land, ur ett geografiskt och ekonomiskt perspektiv,

att arbete i som kirurg, narkosläkare eller förlossningsläkare med utbildning från ett annat land.

Studie V handlar om hur fattigare länder uppfattar den kirurgisk hjälp som de får från många rika länder. Studien är en sammanställning av allt tidigare material som finns utgivet på området. Resultatet visade att många från fattiga länder uppskattar när fokuset ligger på utbildning och förbättring, snarare än att bara operera så mycket som möjligt, vilket kan innebära att administrationsbördan ökar för ordinarie personal eller att kostnaden stiger när fler patienter kan behandlas.

Studie VI handlar om svenska ortopeder, narkosläkare och förlossningsläkares erfarenheter av utomlandsarbete. Här har vi skickat ut en enkät till alla ortopeder, narkosläkare och förlossningsläkare i Sverige och efterfrågat deras intresse för erfarenheter från, barriärer och värden av att arbeta utomlands. Det visade sig att ungefär hälften av de som svarade på enkäten hade arbetat utomlands jämnt fördelat mellan rika och fattiga länder. De var lite vanligare att arbeta utomlands om man var narkosläkare och man efter att ha justerat för kön, specialitet och titel. De flesta som åkt utomlands uppskattade arbetet och såg det som en värdefull erfarenhet medan de som inte hade kunnat arbeta utomlands tyckte det var svårt att hantera familjesituationen och vara bort från det kliniska arbetet hemma.

Sammanfattningsvis visar avhandlingen, genom de sex olika delarbetena, att tillgången till kirurger, narkosläkare och förlossningsläkare är ojämnt fördelat i världen där de fattigaste länderna med den största sjukdomsbördan drabbas hårdast. Rikare länder bör planera sin arbetsmarknad bättre för att undvika att dränera fattiga länder på sin redan blygsamma tillgång till kirurger, narkosläkare och förlossningsläkare samt hjälpa till att bygga upp sjukvårdssystemen där behovet är som störst. Samtidigt som fattiga länder måste skapa långsiktiga lösningar för att öka tillgången till kirurgi, är behovet akut. I kombination med att utbilda fler kirurger, narkosläkare och förlossningsläkare kan fattiga länder vidareutbilda annan vårdpersonal att göra enklare kirurgiska ingrepp eller akuta operationer som annars inte hade kunnat genomföras.

Epilogue

When I was born in 1987, our family, i.e. my parents and my three older brothers, lived in Sri Lanka. I grew up in a rural environment, which was affected by civil war, under the care of two very dedicated parents. My Dad built bridges, and at the time Mom was a midwife working part-time at a local dispensary. When we later moved to Kashmir in Northern India, I started to become aware of society's immense disparities, not least in the access to, and quality of, healthcare. Even though everyone should have access to healthcare, I, as a 6-year-old child, understood that there is no place for cockroaches to be running along corridors in the local healthcare facilitiy…

I was not aware initially that I wanted to pursue a career in medicine. After I had quit my sports career as a result of a recurrent subluxation of the extensor carpi ulnaris, and my Mom had undergone further training to become an obstetrician, I had the chance to attend a Cesarean delivery. While I almost fainted when the patient's uterus was cut open, the amniotic fluid hit the floor and the baby started to scream, I knew that a surgical career was the path ahead for me.

Many years later during medical school in Lund, I met my supervisor, through a friend from school. Lars and Hampus were both very eager and dedicated. They were very inspiring, and even though they worked as hard as 10 people put together, that was not enough. They needed more staff to promote surgery within the field of global healthcare. My motivation was high, and my learning curve was still shallow. After one meeting with them, I was convinced that I wanted to become a global surgical researcher, so I joined them 10 years ago.

I have many great memories during the time that I have worked on this thesis, especially from travelling. For example, when we were teaching a global surgical course at Lund University and we visited Harare, Zimbabwe, for our clinical rotation, or from my trips to Sierra Leone. I had the great fortune to organize and attend the second meeting of The Lancet Commission on Global Surgery in Freetown, Sierra Leone. Another poignant memory stems from when I visited a small hospital run by a non-profit humanitarian organization called CapaCare, which is dedicated to improving medical education and training in developing countries, and aims to increase the number of surgical providers in Sierra Leone. There I met so many inspiring people while I was helping many patients in urgent need of surgical care. From pregnant women with an obstructed labor, to patients with extensive thermal skin burns or gastric perforations as a result of peptic ulceration. During my first night in Sierra Leone, when I was lying in bed listening to the incredible sounds of the jungle outside my window, I thought back to the years when I grew up in the Himalayas. Mom always said that I was born curious and that I rarely accepted "no" for an answer. I am delighted that my curiosity has taken me this far, and hopefully it will continue in my future career.

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Sunrise in Sierra Leone. I would like to dedicate this thesis to the patients and colleagues that I have met over the years, and to my family and friends who have encouraged me greatly and kept me motivated. Photo: Adam Lantz.

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Strengthening the global surgical workforce

The evolution of surgery has been exponential, from crude practice to the development of a sophisticated discipline that embraces new discoveries and continues to push the boundaries of science and what is practically possible. From barbers to physicians to general surgeons, and possibly sub-specialist surgeons, surgery has become an integral components of clinical medicine and health systems. While the broad surgical skill sets of yesterday are becoming increasingly rare among surgeons in high-income countries, most people in the world still cannot access adequate surgical care when required, and most of the world's surgical patients are either operated upon by non-physicians or non-specialists, or they are not treated at all. How can we increase global access to safe, affordable and quality surgical care when required?

Adam Lantz is an orthopedic surgeon practicing in Helsingborg Hospital, Skåne, Sweden. His research has provided data on the global surgical workforce, focusing on access, migration and quality.

The author cutting Professor Lars Hagander's hair in rural Zimbabwe at a barber shop, undertaking teaching at a Lund University Global Surgery course. Photo by Adam Lantz.

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