# Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development

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‡Prof Rodas died March 2, 2015; we dedicate our report to him

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## Executive summary

Remarkable gains have been made in global health in the past 25 years, but progress has not been uniform. Mortality and morbidity from common conditions needing surgery have grown in the world's poorest regions, both in real terms and relative to other health gains. At the same time, development of safe, essential, life-saving surgical and anaesthesia care in low-income and middle-income countries (**LMICs**) has stagnated or regressed. In the absence of surgical care, case-fatality rates are high for common, easily treatable conditions including appendicitis, hernia, fractures, obstructed labour, congenital anomalies, and breast and cervical cancer.

In 2015, many LMICs are facing a multifaceted burden of infectious disease, maternal disease, neonatal disease, non-communicable diseases, and injuries. Surgical and anaesthesia care are essential for the treatment of many of these conditions and represent an integral component of a functional, responsive, and resilient health system. In view of the large projected increase in the incidence of cancer, road traffic injuries, and cardiovascular and metabolic diseases in LMICs, the need for surgical services in these regions will continue to rise substantially from now until 2030. Reduction of death and disability hinges on access to surgical and anaesthesia care, which should be available, affordable, timely, and safe to ensure good coverage, uptake, and outcomes.

Despite growing need, the development and delivery of surgical and anaesthesia care in LMICs has been nearly absent from the global health discourse. Little has been written about the human and economic effect of surgical conditions, the state of surgical care, or the potential strategies for scale-up of surgical services in LMICs. To begin to address these crucial gaps in knowledge, policy, and action, the *Lancet* Commission on Global Surgery was launched in January, 2014. The Commission brought together an international, multidisciplinary team of 25 commissioners, supported by advisors and collaborators in more than 110 countries and six continents.

We formed four working groups that focused on the domains of health-care delivery and management; workforce, training, and education; economics and finance; and information management. Our Commission has five key messages, a set of indicators and recommendations to improve access to safe, affordable surgical and anaesthesia care in LMICs, and a template for a national surgical plan. Our five key messages are presented as follows:

- 5 billion people do not have access to safe, affordable surgical and anaesthesia care when needed. Access is worst in low-income and lower-middle-income countries, where nine of ten people cannot access basic surgical care.
- 143 million additional surgical procedures are needed in LMICs each year to save lives and prevent disability. Of the 313 million procedures undertaken worldwide each year, only 6% occur in the poorest countries, where over a third of the world's population lives. Low operative volumes are associated with high case-fatality rates from common, treatable surgical conditions. Unmet need is greatest in eastern, western, and central sub-Saharan Africa, and south Asia.
- 33 million individuals face catastrophic health expenditure due to payment for surgery and anaesthesia care each year. An additional 48 million cases of catastrophic expenditure are attributable to the non-medical costs of accessing surgical care. A quarter of people who have a surgical procedure will incur financial catastrophe as a result of seeking care. The burden of catastrophic expenditure for surgery is highest in low-income and lower-middle-income countries and, within any country, lands most heavily on poor people.
- Investing in surgical services in LMICs is affordable, saves lives, and promotes economic growth. To meet present and projected population demands, urgent investment in human and physical resources for surgical and anaesthesia care is needed. If LMICs were to scale-up surgical services at rates achieved by the present best-performing LMICs, two-thirds of countries would be able to reach a minimum operative volume of 5000 surgical procedures per 100 000 population by 2030. Without urgent and accelerated investment in surgical scale-up, LMICs will continue to have losses in economic productivity, estimated cumulatively at US $12·3 trillion (2010 US$, purchasing power parity) between 2015 and 2030.
- Surgery is an "indivisible, indispensable part of health care."[1] Surgical and anaesthesia care should be an integral component of a national health system in countries at all levels of development. Surgical services are a prerequisite for the full attainment of local and

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global health goals in areas as diverse as cancer, injury, cardiovascular disease, infection, and reproductive, maternal, neonatal, and child health. Universal health coverage and the health aspirations set out in the post-2015 Sustainable Development Goals will be impossible to achieve without ensuring that surgical and anaesthesia care is available, accessible, safe, timely, and affordable.

In summary, the Commission's key findings show that the human and economic consequences of untreated surgical conditions in LMICs are large and for many years have gone unrecognised. During the past two decades, global health has focused on individual diseases. The development of integrated health services and health systems has been somewhat neglected. As such, surgical care has been afforded low priority in the world's poorest regions. Our report presents a clear challenge to this approach. As a new era of global health begins in 2015, the focus should be on the development of broad-based health-systems solutions, and resources should be allocated accordingly. Surgical care has an incontrovertible, cross-cutting role in achievement of local and global health challenges. It is an important part of the solution to many diseases—for both old threats and new challenges—and a crucial component of a functional, responsive, and resilient health system. The health gains from scaling up surgical care in LMICs are great and the economic benefits substantial. They accrue across all disease-cause categories and at all stages of life, but especially benefit our youth and young adult populations. The provision of safe and affordable surgical and anaesthesia care when needed not only reduces premature death and disability, but also boosts welfare, economic productivity, capacity, and freedoms, contributing to long-term development. Our six core surgical indicators (table 1) should be tracked and reported by all countries and global health organisations, such as the World Bank through the World Development Indicators, WHO through the Global Reference List of 100 Core Health Indicators, and entities tracking the SDGs.

At the opening meeting of the *Lancet* Commission on Global Surgery in January, 2014, Jim Kim, President of the World Bank, stated that: "surgery is an indivisible, indispensable part of health care" and "can help millions of people lead healthier, more productive lives".[1]

In 2015, good reason exists to ensure that access to surgical and anaesthesia care is realised for all.

## Introduction

The urgent need for surgical care in the world's poorest regions is widely unrecognised. In 2010, an estimated 16·9 million lives (32·9% of all deaths worldwide) were lost from conditions needing surgical care.[2] This figure well surpassed the number of deaths from HIV/AIDS (1·46 million), tuberculosis (1·20 million), and malaria (1·17 million) combined.[3] Each year, at least 77·2 million disability-adjusted life-years (DALYs) could be averted by basic, life-saving surgical care.[4] As with so many global health challenges, the burden of untreated surgical conditions falls heaviest on individuals living in low-income and middle-income countries (LMICs).[4,5] Within LMICs, people with the lowest income, those living in rural areas, and those who are marginalised fare the worst.[6] Although, on average, one procedure is done per ten people living in high-income countries each year (appendix p 8),[7] access to an operating room is out of reach for billions of people worldwide.[8] In the absence of surgical care, common, easily treatable illnesses become diseases with high fatality rates. Yet because conditions needing surgical care have diverse

| | Definition | Target |
|---|---|---|
| Access to timely essential surgery | Proportion of the population that can access, within 2 h, a facility that can do caesarean delivery, laparotomy, and treatment of open fracture (the Bellwether Procedures) | A minimum of 80% coverage of essential surgical and anaesthesia services per country by 2030 |
| Specialist surgical workforce density | Number of specialist surgical, anaesthetic, and obstetric physicians who are working, per 100 000 population | 100% of countries with at least 20 surgical, anaesthetic, and obstetric physicians per 100 000 population by 2030 |
| Surgical volume | Procedures done in an operating theatre, per 100 000 population per year | 80% of countries by 2020 and 100% of countries by 2030 tracking surgical volume; a minimum of 5000 procedures per 100 000 population by 2030 |
| Perioperative mortality | All-cause death rate before discharge in patients who have undergone a procedure in an operating theatre, divided by the total number of procedures, presented as a percentage | 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 anaesthesia care | 100% protection against impoverishment from out-of-pocket payments for surgical and anaesthesia care by 2030 |
| Protection against catastrophic expenditure | Proportion of households protected against catastrophic expenditure from direct out-of-pocket payments for surgical and anaesthesia care | 100% protection against catastrophic expenditure from out-of-pocket payments for surgical and anaesthesia care by 2030 |

These indicators provide the most information when used and interpreted together; no single indicator provides an adequate representation of surgical and anaesthesia care when analysed independently.

***Table 1:*** **Core indicators for monitoring of universal access to safe, affordable surgical and anaesthesia care when needed**

causes—including infection, cancer, injury, and disorders relating to reproductive, maternal, and child health—their impact has been poorly captured within present epidemiological frameworks that focus on disease causes, not treatment needs.[3,9–11] Death and disability from conditions needing surgical care in LMICs have received little attention. This is not merely unjust; failure to recognise and address the substantial human and economic toll of untreated surgical conditions in LMICs slows progress towards a diverse range of health and development goals.

Surgical care should be an integral component of health systems for countries at all levels of development.[12] As many LMICs undergo an epidemiological transition over the next 20 years, cancer, cardiovascular disease, and road traffic injuries are poised to surpass previous communicable disease challenges. As a result, the need for equitable access to surgical services in these countries is projected to substantially increase. Yet despite the large and growing unmet need for surgical care worldwide, securing a place for surgery and anaesthesia within the present global health framework of disease-based monitoring and advocacy is still exceptionally difficult.

In response to these challenges, the *Lancet* Commission on Global Surgery was launched in January, 2014, during a crucial transition period in global health. The lead-up to the year 2015 saw a renewed global commitment to the notion of universal health coverage (UHC), a revisiting of strategic investments in global health, and deliberation over how the world's health goals would be represented in the post-2015 Sustainable Development Goals (SDGs). Within this changing global health landscape, we aimed to examine the case for surgery as an integral component of health care, focusing on LMICs; assess the crucial challenges and key opportunities in the development and delivery of quality surgical and anaesthesia services in resource-poor settings; and propose a series of key policy recommendations and indicators to guide future progress. In 2014, three commissioner meetings were held: in Boston, USA; Freetown, Sierra Leone; and Dubai, United Arab Emirates. These meetings brought together an international team of 25 commissioners with skills in the specialties of surgery, anaesthesia, nursing, global health, health policy, and management and finance, and invited advisors, researchers, and contributors, from more than 110 countries. Each commissioner was assigned to one of four working groups providing in-depth analyses into the areas of health-care delivery and management; workforce, training, and education; economics and finance; and information management. We followed a collaborative process and method (appendix pp 3–7) to engage effectively with stakeholders and build an inclusive global surgical movement. Commissioners engaged in direct outreach efforts with ministries of health, front line providers and implementers, global health organisations and funders, professional societies, academia and industry, educators, students, and patients. We also identified knowledge gaps and embarked on collaborative research projects to begin to address them. This research informs all sections of the report and appendices. Web-based platforms and social media promoted global engagement. Lastly, 12 teaching cases were written in collaboration with five business schools and one global health programme in the USA, Australia, and India. These cases were modelled on the business school case-method pedagogy and nested in real country-level examples of surgical and anaesthesia care provision and systems strengthening in LMICs.

Although the need for surgery extends across countries at all stages of development, the largest area of unmet need exists within LMICs. Therefore, surgical care within LMICs, rather than high-income countries, was the primary focus of the Commission. Global surgery, as defined previously,[13] refers to all groups facing inequitable or inadequate surgical care delivery, whether they are chronically underserved populations or those in acute crisis, conflict, or disaster settings. The factors driving surgical need and the mechanisms for improvement of surgical care for these populations, however, are often very different. Therefore, we restricted our work and scope to underserved populations in LMICs, outside of mass conflict and disaster settings (panel 1).

In this report, we present the findings of the Commission. We describe the Commission's key messages, present findings from the four working group areas, outline future research needs, and finally provide a template for the development of a national surgical plan. We conclude each section by outlining policy recommendations for stakeholders involved in the delivery of surgical care at local, national, and global levels.

Our hope is that the Commission's findings will draw attention to the gross disparities that exist worldwide in surgical care, and the far-reaching human and economic consequences that result in lost lives, lost potential, and lost output. We also hope that this report serves as a catalyst and provides an early framework to effect change. The problems are clear. The solutions will need continuing development, testing, and refinement. Only through a unified commitment to research, advocacy, policy development, and investment, accompanied by coordinated local and international action, will this Commission's vision of universal access to safe, affordable surgical and anaesthesia care when needed be realised in our global community.

## Key messages of inequity and impact

### The complexity of measuring surgical conditions

In this section, we quantify and characterise the burden of surgical conditions. By synthesising existing published work and the results of new primary research, we look at access to surgery and anaesthesia, unmet need for surgical procedures, and the financial effect of seeking surgical services. We then examine the macroeconomic

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See **Online** for appendix

**LMICs**
Although this term has been used throughout the report for brevity, the Commission realises that tremendous income diversity exists between and within this group of countries

*Panel 1:* **Definitions**

**Global Surgery**
An area of study, research, practice, and advocacy that seeks to improve health outcomes and achieve health equity for all people who need surgical and anaesthesia care, with a special emphasis on underserved populations and populations in crisis. It uses collaborative, cross-sectoral, and transnational approaches and is a synthesis of population-based strategies with individual surgical and anaesthesia care.[14]

**Surgical care**
The provision of operative, perioperative, and non-operative management; anaesthesia; and obstetric care for all surgical conditions.

**Surgical condition**
Any disease, illness, or injury in which surgical care can potentially improve the outcome.[15]

**Surgical provider**
Any health worker providing surgical care, including obstetric and gynaecological surgical care, irrespective of level of training or supervision.

**Anaesthetic provider**
Any health worker providing anaesthetic care, irrespective of level of training or supervision.

**The surgical workforce**
A network of associated surgical and anaesthetic personnel who work in concert to deliver surgical care. This includes but is not limited to all surgical and anaesthetic providers, nurses, pathologists, radiologists, laboratory technicians, theatre managers, community health workers, rehabilitation specialists, biomedical technicians, and engineers.

**Specialist surgical workforce**
Fully trained physician surgeons, anaesthetists, and obstetricians, synonymous with consultant and attending surgeon, anaesthetist, or obstetrician.

**Associate clinician**
A health worker trained specifically to diagnose and manage basic medical and surgical conditions who is not a physician. Some might undertake surgery.[16] They might also be referred to as non-physician clinicians, mid-level providers, clinical officers, or *técnicos de medicina y cirugía*.[17]

**First-level hospital**
First-referral-level hospital or the district hospital provides a level of care that cannot be obtained at home; acts as a gatekeeper for referral to higher levels of care at a secondary or tertiary hospital.

**Essential surgical care**
Any and all procedures, contextually and culturally dependent, that are deemed by that region, society, or culture to promote individual and public health, wellbeing, and economic prosperity. The Bellwether Procedures—caesarean delivery, laparotomy and open fracture treatment—serve as a proxy for surgical systems that have the ability to provide a broad range of procedures.

impact of surgical conditions in LMICs. Finally, we outline the fundamental and cross-cutting role of surgery and anaesthesia in the achievement of widespread gains in global health, welfare, and development.

Many challenges to the accurate and comprehensive measurement of the global burden of disease exist.[14,15] In many LMICs, country-specific health data is scarce.[16–20] Most disease burden estimates are not based on gold-standard pathological or even subjective clinical diagnoses; rather, they are extrapolated from various less concrete methods including demographic surveillance systems, household surveys, verbal autopsies, facility-level data inquiries, and a mixture of modelling methods. Although modelling approaches are invaluable methods to understand human health and disease, their results are estimates, and concerns exist about their reliability, applicability, and consistency.[14,15,21]

Unlike a discrete disease entity, surgery is a treatment modality and is needed across the entire range of human disease. The scope of this need further complicates measurement of the prevalence and effect of surgical conditions. Research shows that major procedures are undertaken in every disease subcategory defined by the Global Burden of Disease (GBD) study (figure 1)[9]; at least 15% of pregnancies result in complications that need emergency obstetric care, including surgical management;[22,23] and surgery is responsible for roughly 65% of all cancer cure and control.[24] Although not every trauma patient who has a severe physical injury needs a surgical procedure, care of injured patients almost always needs the skill of a surgically trained provider.

Even when the need for surgery is clearly identified, it is difficult to classify and measure, because no universal nosology for surgical conditions or treatment exists. Surgery's cross-cutting nature means that classification of surgical conditions overlaps with classification of all other disease subsets. For example, is colon cancer—incurable without surgical intervention—characterised as a surgical condition or a malignancy? Is sepsis from an infected diabetic foot wound necessitating amputation an infectious disease, endocrine disorder, or surgical ailment? Is obstructed labour, for which instrumental or operative intervention is the only definitive treatment, considered a maternal health or surgical problem?

Although surgical need transects all disease categories, the necessity for surgery varies from one region to the next depending on disease patterns, social determinants, and the availability and use of medical care. Poor access to care and delayed medical interventions mean that pathological abnormalities generally not needing surgery in settings with strong primary health-care systems might progress to need operative intervention when left unattended. For example, in the post-antibiotic era, pneumococcal pneumonia and tuberculosis are not typically regarded as surgical conditions; neither are many superficial skin infections. However, if not diagnosed and treated promptly, microbial pathogens can lead to serious surgical pathological abnormalities such as empyema, osteomyelitis, and rheumatic heart disease.

## Estimates of the global burden of surgical conditions

Despite difficulties in the measurement and definition of the global burden of surgical conditions, three attempts have been made. All attempts rely on the burden of disease methods described in the appendix pp 11–12. The

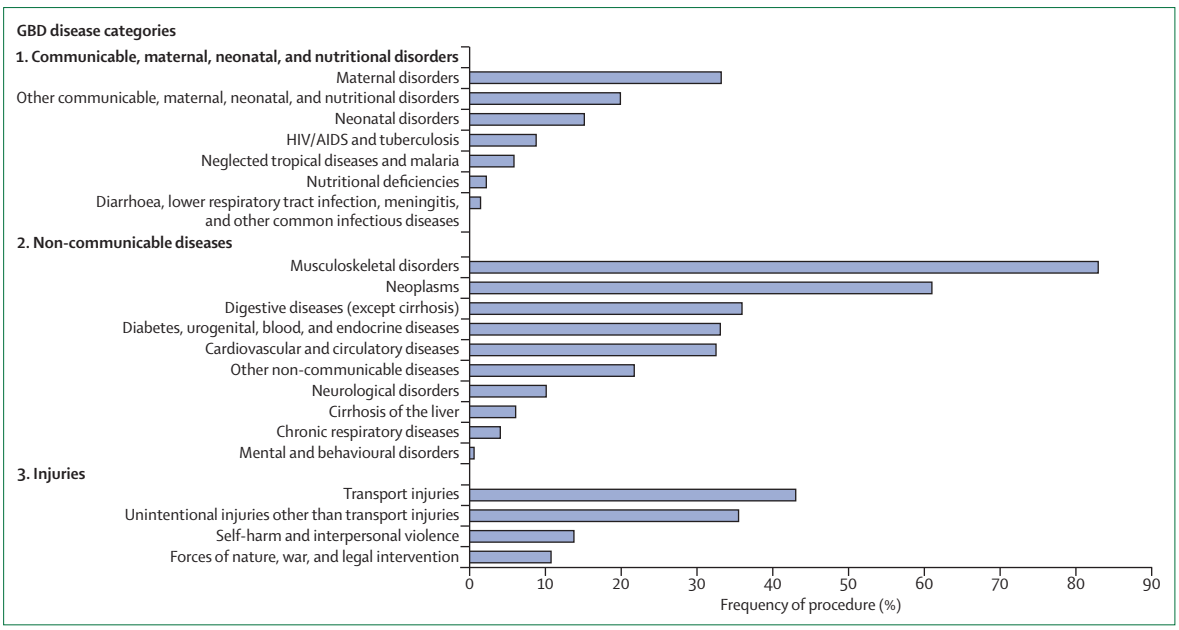



***Figure 1:*** **Frequency of operations done per GBD 2010 disease category for patients admitted to hospitals in a well resourced health system**
Data from Rose and colleagues.[9] GBD=Global Burden of Disease.

first and most widely cited estimate was generated after 18 surgeons from around the world provided estimates for "the proportion of each condition [from the 2002 World Health Report burden of disease estimates] that would require surgery" based on their professional experiences.[5] After excluding the two highest and two lowest estimates, the investigators concluded that at least 11% of global DALYs were surgical.[5]

The second was derived in consideration of the reduction in morbidity and mortality from scaling up a basic surgical package that could be provided at first-level hospitals in LMICs. This package included treatments for four digestive disorders, four maternal–neonatal disorders, and injuries that could be treated with basic interventions.[4] After assuming a counterfactual scenario in which mortality and morbidity were equal to the best performing regions on the basis of the Institute for Health Metrics and Evaluation (IHME) estimates, the researchers estimated that 1·4 million deaths could be prevented annually.[4] The avertable and non-avertable mortality and morbidity from this small number of surgical conditions within the three specific categories examined accounted for 14·2% of the total burden of disease in LMICs.[4]

The third was done as part of this Commission.[2] Surgeons, anaesthesiologists, internists, nurses, and public health practitioners from around the world were surveyed. For each of the 21 IHME cause groups, they were asked: "What proportion of patients with the following conditions would, in an ideal world, require a surgeon for management?" 173 people returned the surveys, including six anaesthesia providers, 36 general surgeons, and 46 specialists. Depending on the method of estimation and definition of burden used (death *vs* DALYs), they reported that surgical conditions account for 28–32% of the overall global burden of disease.

## Key message 1

### *5 billion people lack access to safe, affordable surgical and anaesthesia care when needed*

Access to surgical care is essential for reduction of mortality and morbidity from surgical conditions. Previous estimates reported that more than 2 billion people have no access to surgery and anaesthesia.[8] This figure is probably an underestimate, because it was calculated using just one dimension: operating theatre density.[8] The notion of access to care is multidimensional, encompassing geographic, temporal, structural, socio-cultural, financial, and political components. For a patient to access surgical and anaesthesia care, a delivery system (including trained personnel and physical resources) should first exist. The patient should then be able to reach this system in a timely manner. For the patient to benefit, the care should be safe and effective. Finally, the costs of surgical and anaesthesia services should not act as a barrier to uptake, or result in financial catastrophe for patients and their families. Consideration of these dimensions suggests a greater deficiency of access than previously estimated.

Our vision is universal access to safe, affordable surgical and anaesthesia care when needed. To quantify a more comprehensive assessment of access in terms of this vision, we created a mathematical model to show

how many people worldwide are unable to receive safe, timely surgical and anaesthesia care with financial protection. We defined access to surgery in a specific country by the following four components: existence of surgical capacity in terms of workforce and infrastructure; ability to obtain surgical and anaesthesia care in a timely way; a safe way; and an affordable way.

We constructed a chance tree to model the probability that an individual has access to surgery and anaesthesia using a binary outcome of access (1) or no access (0).[25] Each chance node represented the probability of an access dimension being available to an individual patient conditional on the previous dimensions. Raw data for each dimension were not widely available so proxy measures were used. We assessed timeliness (first dimension) by the proportion of serious injuries transported by ambulance,[26] surgical capacity (second dimension) by the number of surgical procedures undertaken in a country as a proportion of number of surgeries needed,[27] safety (third dimension) by the proportion of operating rooms with pulse oximetry,[8] and affordability (fourth dimension) by the proportion of patients undergoing surgery who do not experience catastrophic expenditure.[28]

Since access most likely varies between urban and rural populations, we did a secondary analysis[25] (selective tree) in which all four dimensions were applied to rural populations, but only the third and fourth dimensions (safety and affordability) were applied to urban populations to create a lower bound estimate. The application of all four dimensions to the entire population is termed the full tree and is an upper bound estimate. A full discussion of the methods can be found in the accompanying paper."[25]

The selective and full trees show that 4·8 billion (95% posterior credible interval [PCI] 4·5–5·0) and 5·3 billion (5·0–5·5) people, respectively, do not have access to safe, timely surgical and anaesthesia care when needed with financial protection, and most of these people reside in the poorest regions of the world. In countries designated as low-income and lower-middle-income countries by the world bank, the selective tree estimates that 94% of the population does not have access to safe surgical and anaesthesia care that is timely and affordable, compared with 14·9% of the population in high-income countries. When results from the selective tree are stratified by IHME super-region, 93% of the population in sub-Saharan Africa and 97% of the population in South Asia do not have access, compared with 3·6% in higher-income regions (figure 2). These numbers are large but not unexpected considering that

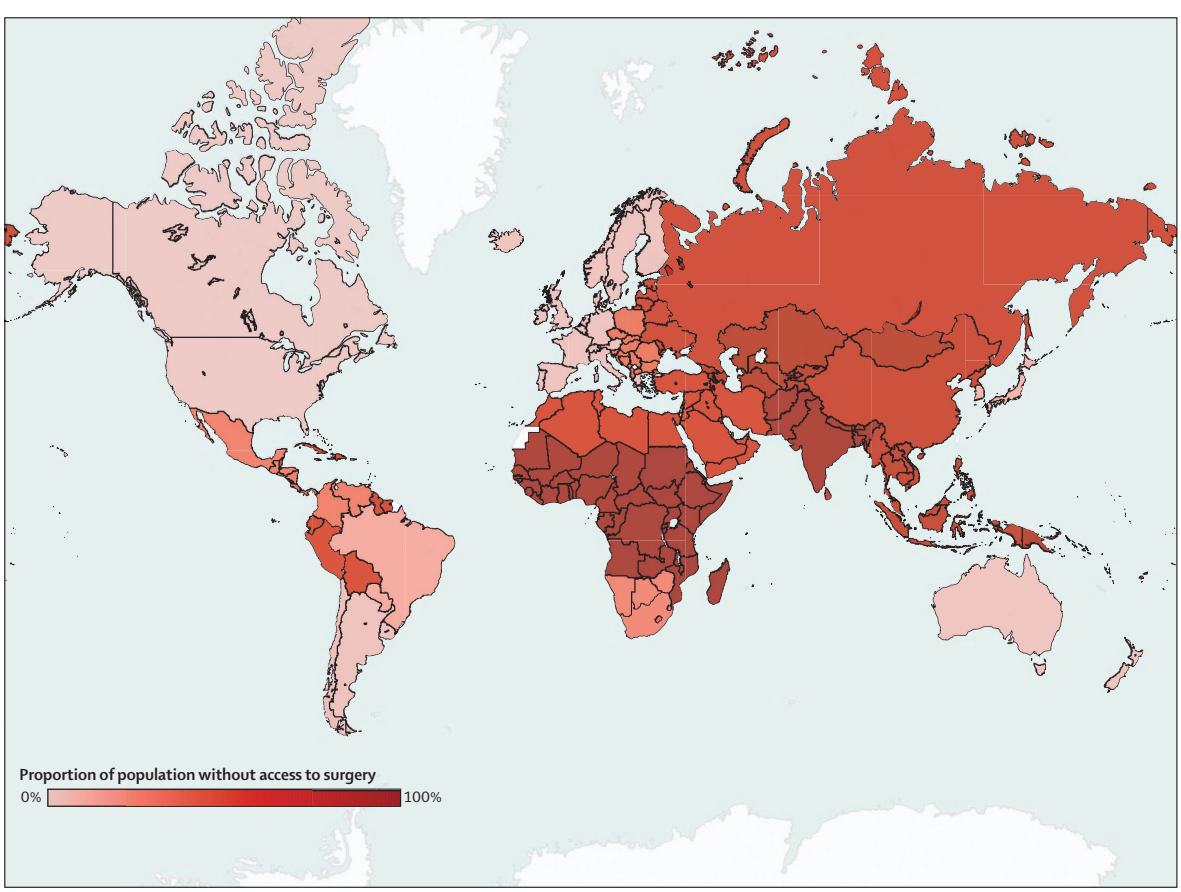



*Figure 2:* **Proportion of the population without access to safe, affordable surgery and anaesthesia by Institute for Health Metrics and Evaluation region (selective tree)[25,29]**

our definition of access goes beyond geographic terms and basic service delivery to encompass the additional dimensions of timeliness, safety, and affordability.

This access chasm is consistent with existing evidence. Of an estimated 312·9 million surgical procedures undertaken worldwide in 2012, only 6·3% were done in countries comprising the poorest 37·3% of the world's population.[7] Assessment of access to emergency obstetric care in Uganda, Kenya, South Sudan, and Rwanda showed that only 2·1–18·5% of expected direct obstetric complications were treated, and that caesarean delivery as a proportion of all births was between 0·1% and 1%.[30] An estimated 951 million women are without access to emergency obstetric care should they become pregnant.[31] Similarly, assessment of stage of presentation and outcomes of patients with breast cancer in Uganda suggests that patients either cannot, or do not, access necessary care in a timely way.[32] More than 77% of patients presented with stage III or IV disease,[32] compared with 11% in the USA.[33]

Inadequate access to surgical and anaesthesia care is deadly. A nationally representative population-based study of deaths from acute abdominal conditions in India reported that postal code areas with high age-standardised acute abdominal mortality were more likely to be located further from a hospital capable of providing appropriate emergency surgical care than were areas with low mortality. When the distance to the nearest well resourced hospital was more than 100 km, the odds ratio of living in a high mortality area compared with a low mortality area was 16·1 (95% CI 7·9–32·8), even after adjusting for socioeconomic status and belonging to a scheduled caste or tribe (appendix p 13).[34]

### Key message 2

*143 million additional surgical procedures are needed each year to save lives and prevent disability*

An understanding of unmet surgical need is fundamental to the improvement of surgical care in LMICs. We are not aware of any worldwide estimate that translates absence of access to surgical and anaesthesia services into unmet need for surgical care, or how many surgical procedures might be needed to address disease prevalence. To assess how surgical and anaesthesia provision could affect disease burden, we did a three-step analysis at the worldwide level to identify minimum surgical need, met surgical need, and unmet surgical need. Full methods and results can be found in the accompanying papers (appendix p 8).[7,27,35]

We first measured the recorded frequency of surgery per condition. Because surgery is a facility-based intervention, the relation between admission diagnosis and subsequent undertaking of an operation in a well functioning and nationalised health-care system allowed us to estimate operative need on the basis of diagnostic categories. This estimation has previously been calculated for the USA.[9] However, the USA is an outlier in terms of its operative volumes[36] and health-care expenditure per person,[37] making it a poor model for determination of ideal or feasible surgical rates. To generate a more realistic model estimating overall surgical need, we queried New Zealand's national health-care database. New Zealand has a high-quality health-care system with good population coverage and reasonable per-person spending; we used data from the New Zealand database to calculate frequency of operation (any procedure needing general or neuroaxial anaesthesia) per WHO Global Health Estimate (GHE) disease subcategory based on admission diagnosis codes (appendix p 14).

We then applied the estimated surgical frequency for each disease subcategory to condition prevalence data (obtained from GBD 2010[10]) for each of the 21 GBD regions; this generated crude estimates of surgical need per condition for each geographic region (total need). Finally, we updated estimates of surgical volume for each country (met need),[7] and calculated unmet need by subtracting met need from total need.

Consistent with previous findings,[9] we noted that surgical care is needed in some way for all GHE disease subcategories. Minimum estimated need was very large—321 million surgical procedures worldwide—and geographically variable, ranging from 3384 operations per 100 000 population in central Latin America to 6495 procedures per 100 000 population in western sub-Saharan Africa. Of the 21 GBD regions, we calculated that 12 do not do enough procedures to address the basic surgical needs of their populations. These regions had an unmet need ranging from 301 to 5625 cases per 100 000 population, totalling 143 million procedures. The regions with the greatest unmet need per 100 000 population were western, eastern, and central sub-Saharan Africa, followed by south and southeast Asia (table 2).

These methods probably underestimate actual surgical need within a region. Surgical rates in New Zealand do not cover all needed surgery in the country;[38] the New Zealand admission database only includes inpatient procedures, and since GBD prevalence data are missing from many disease subcategories, extrapolated global surgical need underestimates ideal rates. Finally, the need for surgery will vary from one region to the next owing to many factors, such as disease progression, on the basis of available care. Because New Zealand's health-care population coverage is quite good, progression of some conditions to needing surgical care is less likely compared with systems with weaker health services. Therefore, our annual unmet need estimate of 143 million additional precedures is probably conservative.

### Key message 3

*33 million individuals face catastrophic health expenditure due to payment for surgery and anaesthesia each year*

Protection against catastrophic out-of-pocket (OOP) health-care expenditure is essential.[39] Global health and

| | Population size of region (millions) | Estimated total need of region | | Estimated unmet need* of region | |
|---|---|---|---|---|---|
| | | Surgical cases (millions) | Cases per 100 000 population | Surgical cases | Cases per 100 000 population |
| Andean Latin America | 53 | 2·0 | 3773 | 0 | 0 |
| Australasia | 26 | 1·2 | 4669 | 0 | 0 |
| Caribbean | 44 | 2·2 | 5080 | 131 050 | 301 |
| Central Asia | 80 | 3·5 | 4339 | 910 432 | 1136 |
| Central Europe | 119 | 6·6 | 5515 | 678 358 | 570 |
| Central Latin America | 231 | 7·8 | 3384 | 0 | 0 |
| Central sub-Saharan Africa | 97 | 6·0 | 6255 | 4 192 980 | 4343 |
| East Asia | 1398 | 57·8 | 4136 | 27 956 507 | 2000 |
| Eastern Europe | 207 | 10·3 | 4967 | 0 | 0 |
| Eastern sub-Saharan Africa | 356 | 21·9 | 6145 | 17 555 748 | 4935 |
| High-income Asia Pacific | 178 | 9·4 | 5291 | 0 | 0 |
| High-income North America | 340 | 15·8 | 4647 | 0 | 0 |
| North Africa and Middle East | 446 | 19·8 | 4456 | 2 115 011 | 474 |
| Oceania | 10 | 0·4 | 4501 | 55 196 | 555 |
| South Asia | 1613 | 72·9 | 4520 | 57 791 550 | 3582 |
| Southeast Asia | 610 | 25·8 | 4225 | 12 480 939 | 2045 |
| Southern Latin America | 60 | 3·0 | 4906 | 0 | 0 |
| Southern sub-Saharan Africa | 70 | 3·6 | 5093 | 291 000 | 413 |
| Tropical Latin America | 202 | 7·2 | 3581 | 0 | 0 |
| Western Europe | 416 | 22·3 | 5366 | 0 | 0 |
| Western sub-Saharan Africa | 336 | 21·8 | 6495 | 18 909 507 | 5625 |
| Global total | 6893 | 321·3 | .. | 143 068 278 | .. |

Data are from Rose and colleagues[27] based on calculations provided by Weiser and colleagues[7] and Hider and colleagues.[35] *There is a modelling artifact in the regions that seem to have an unmet need of zero. In these regions, countries with higher surgical rates skew the regional unmet need, even though great disparities in unmet need for surgery might still exist. This is why surgical need should be measured at the country or possibly even the sub-national level for large countries to achieve the sensitivity needed to identify true surgical need. As such, this model underestimates the surgical need in all regions owing to this averaging effect.

***Table 2:*** **Estimated minimum total need and unmet need for surgery by Global Burden of Disease epidemiological region**

development organisations have recently supported prioritisation of financial risk protection within UHC,[39–42] and the World Bank and WHO have targeted 100% financial protection from catastrophic expenditure from OOP payments for health services by 2030.[39] OOP payments for health care are the predominant form of health financing in many regions,[43] and an estimated 150 million people face financial catastrophe every year from direct OOP costs of medical care.[44] Data for financial costs of care for a small number of surgical conditions in individual countries or regions show substantial catastrophic expenditure.[45–47] However, little is known about the magnitude of OOP payments for surgical services on a worldwide scale.

To elucidate the contribution of OOP payments for surgery to overall catastrophic health expenditure, we estimated the financial effects of accessing surgical services. We looked at three primary outcomes of accessing surgical and anaesthesia care: the annual number of cases of catastrophic expenditure from OOP medical costs, the annual number of cases of catastrophic expenditure from OOP non-medical costs, and the number of people at risk of catastrophic expenditure should they need surgical and anaesthesia care. Full methods can be found in the accompanying paper.[28]

We calculated that an estimated 32·8 million (95% PCI 32·4–33·1) cases of catastrophic expenditure occur directly from the medical cost of accessing surgical services annually. This value represents roughly 22% of the previously estimated 150 million people who endure catastrophic expenditure from accessing all types of health care,[44] and is similar to the proportion of global disease burden that is surgical.[2,4] However, these numbers underrepresent financial ruin secondary to disease, because they do not include potentially impoverishing non-medical costs of accessing care, such as for transportation, lodging, and food. When non-medical costs were considered in the model, we noted that an additional 48 million cases of catastrophic expenditure occur annually. This amount results in 81·2 million (95% PCI 80·8–81·7) annual cases of catastrophic expenditure attributable to accessing surgical care. Finally, we noted that half the world's population, or 3·7 billion (95% PCI 3·2–4·2) people, are at risk of catastrophic expenditure if they were to need surgery because they do not have financial risk protection. Most of these individuals live in sub-Saharan Africa and south and southeast Asia.

This financial burden is shouldered mainly by poor people. Both the risk for, and the occurrence of, financial catastrophe fall primarily on individuals from LMICs and, within any country-income level, on the poorest wealth quintiles (figure 3). On a worldwide scale, we calculated that the poorest patients are 61 times more likely to face catastrophic expenditure compared with the richest patients. This inequity becomes increasingly more prominent with increasing country gross national income (GNI) per person. In low-income countries, 12% of the poorest four quintiles face catastrophic expenditure compared with 7·5% of the richest quintile. However, in upper-middle and high-income countries, nearly all catastrophic expenditure falls on people who have a low income.

Our calculations of the number of cases of catastrophic expenditure that result from accessing surgical care (81·2 million annual cases) do not take into account patients who are not able to access surgical and anaesthesia care in the first place, whether as a result of the absence of appropriate systems or failure of resource allocation. We note that the proportion of the population incurring financial catastrophe from accessing surgery is actually higher in lower-middle-income countries than in low-income countries, probably because of an inability of the poorest people to reach appropriate services.

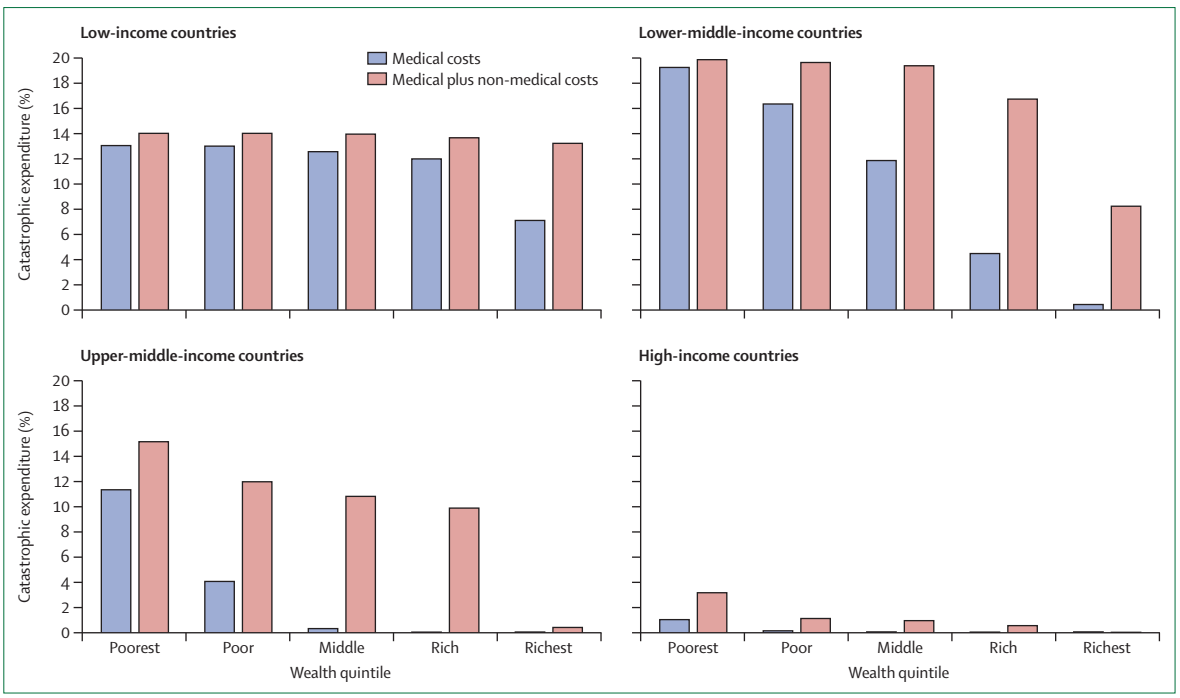



*Figure 3:* **Risk of catastrophic expenditure due to costs of seeking surgery, by wealth quintile and income of country**[28]
Data with and without non-medical costs (eg, transportation, lodging, and food) are shown.

## Key message 4

*Investment in surgical and anaesthesia services is affordable, saves lives, and promotes economic growth*

Scaling up basic surgical and anaesthesia care is a necessary step in the improvement of global health. The third edition of Disease Control Priorities reports that scaling up surgical services to treat three sets of conditions could prevent 3·2% of annual deaths and 3·5% of DALYs in LMICs.[4] However, the financial cost of broad surgical scale-up has not been previously recorded. To assess the financial feasibility and economic effect of surgical expansion, we assessed the scale-up and development of surgical and anaesthesia services from 2012 to 2030 using one historical rate and two aspirational rates of increase.[48]

A complete discussion of methodology can be found in the accompanying paper.[48] Briefly, we assumed that high-income countries have the capacity to undertake an adequate number of procedures to meet essential surgical needs of their populations and therefore restricted our analysis to LMICs. The historical scale-up rate (5·1% per year) was established using surgical volume data and a GNI per-person time series to estimate the level of surgical and anaesthesia care countries would be expected to achieve by 2030 in view of their income. The two rates of aspirational scale-up were surgical volume growth rates of 8·9% per year achieved in Mongolia,[49] and 22·5% per year achieved in Mexico (based on data from the Mexican Ministry of Health). We then calculated the year by which each of 103 LMICs would achieve a target surgical rate of 5000 cases per 100 000 population using these three rates of expansion, and the costs associated with achieving such a scale-up. Costs were divided into a unit cost for surgical procedures and construction costs for facilities and operating theatres (table 3).

Although any proposed surgical rate is arbitrary, we chose 5000 procedures per 100 000 population as a minimum threshold target on the basis of a surprisingly narrow range of recorded rates of surgery associated with desirable health outcomes: a life expectancy of 74–75 years, a mate rnal mortality ratio of 100 women per 100 000 live births or less, and the estimated minimum need for surgery described in key message 2.[50]

15 (15%) of the 103 countries had already achieved the target volume in 2012. Therefore, these countries were removed from subsequent analysis. The 88 countries remaining, which include China, India, and South Africa, represent more than 70% of the world's population. Using historical rates of increase, 39 (44%) of the 88 countries could achieve the target by 2030. Using aspirational Mongolian rates of increase, 59 (67%) of the 88 countries would achieve the target by 2030, whereas all countries would achieve the target by 2030 using aspirational Mexican rates of increase.

Total costs were calculated for historical, Mongolian, and Mexican rates of increase for each country income group. Costs to expand surgical services between 2012 and 2030 for the 88 LMICs are about US$300 billion ($16 billion annually) with historic rates of increase, $420 billion ($23 billion annually) with Mongolian

| | Low-income countries | Lower-middle-income countries | Upper-middle-income countries |
|---|---|---|---|
| Unit cost for surgical procedures | 179 | 219 | 332 |
| Surgical theatre construction cost | 319 002 | 412 488 | 1 906 064 |
| Historical rates of increase (5·1% per year) | | | |
| Cost of surgical procedures | 14 | 115 | 86 |
| Costs of operating rooms | 6 | 37 | 40 |
| Total cost | 20 | 152 | 126 |
| Annual cost (% of total annual health expenditure) | 1 billion (4%) | 8 billion (4%) | 7 billion (1%) |
| Mongolian rates of increase (8·9% per year) | | | |
| Cost of surgical procedures | 31 | 197 | 91 |
| Costs of operating rooms | 13 | 50 | 40 |
| Total cost | 44 | 247 | 131 |
| Annual cost (% of total annual health expenditure) | 2 billion (8%) | 14 billion (6%) | 7 billion (1%) |
| Mexican rates of increase (22·5% per year) | | | |
| Cost of surgical procedures | 76 | 274 | 95 |
| Costs of operating rooms | 17 | 50 | 40 |
| Total cost | 93 | 324 | 135 |
| Annual cost (% of total annual health expenditure) | 5 billion (17%) | 18 billion (8%) | 8 billion (1%) |

Costs are presented per billion 2012 US$. Estimates are from Verguet and colleagues[48] created specifically for this Commission.

***Table 3*: Total and annual costs of scaling up basic surgical services from 2012 to 2030 using historical, Mongolian, and Mexican rates of increase for 33 low-income countries, 33 lower-middle-income countries, and 22 upper-middle-income countries**

rates of increase, and $550 billion ($31 billion annually) with Mexican rates of increase.

Although Mexican rates of increase are too ambitious to use as a realistic global target, reaching historical and Mongolian rates is feasible if scaling up of surgical services was prioritised. The historical and Mongolian rates of increase are similar to rates of decline seen in LMICs for under-5 mortality and maternal mortality, two areas of prominent global health focus.[51,52] Although the total costs of scale-up are substantial, research suggests that surgery is a highly cost-effective intervention,[53,54] and the percentage of annual health expenditure is proportionate to the percentage of the total burden of disease that needs surgical intervention in these countries.

Expansion of surgical and anaesthesia care might result in substantial economic returns on investment. Macroeconomic assessment of other global health foci have shown that health improvements lead to both improved life expectancy and improved national income,[55,56] but similar work has not been done for a comprehensive subset of surgical conditions. To assess the economic consequences of untreated surgical conditions, we examined five major disease categories needing essential surgery: neoplasms, injuries, maternal disorders, neonatal disorders, and digestive disorders. Full details of this methodology can be found in the accompanying paper.[57] Briefly, we estimated the total value of lost economic output secondary to these surgical conditions between 2015 and 2030 using the WHO Projecting the Economic Cost of Ill-Health (EPIC) model. The EPIC model projects how disease affects a country's labour supply and capital stock, which in turn are related to aggregate economic output (ie, GDP) over time, thereby linking disease to economic growth.[55] The counterfactual is assumed to be no disease.

The value of lost output secondary to surgical conditions was estimated for 128 countries with a combined population of 6·4 billion people (in 2013), or 90% of the world population. We noted that between 2015 and 2030, surgical conditions will be responsible for a cumulative loss to the global economy of $20·7 trillion or 1·3% of projected economic output. Neoplasms and injuries needing surgical care will have the greatest effect on economic output, followed by digestive diseases. More than half of all losses between 2015 and 2030 will occur in LMICs ($12·3 trillion), particularly in LMIC super-regions of southeast Asia, east Asia, and Oceania ($6·1 trillion; figure 4).

LMICs will bear the brunt of these losses: by 2030 we calculated that surgical conditions in middle-income countries could consume as much as 2% of these countries' projected annual GDP growth. These numbers make the roughly $420 billion investment needed to scale-up services to treat these conditions pale in comparison.

## Key message 5

*Surgery is an indivisible, indispensable part of health care*

Universal access to safe, affordable surgical and anaesthesia care is essential for widespread and equitable improvements in global health, welfare, and development. Surgical conditions consist of a large and diverse collection of human ailments. More than 100 000 maternal deaths might be averted by timely intervention, and increased access to caesarean delivery reduces neonatal mortality by 30–70%.[58] Similarly, non-communicable diseases and injuries are already the largest subset of the global disease burden and are set to rise exponentially in coming years.[59] Prevention and treatment of surgical conditions are necessary to improve the health of populations,[10] are fundamental parts of resilient health systems, and are crucial for the achievement of global health goals. Whether to reach unmet targets of Millennium Development Goals (MDGs) 4 and 5, or to combat the rising tide of malignancies, diabetes, and road traffic injuries, the need for integration of surgical services into comprehensive platforms of health-care delivery is clear.

In 1980, the then director-general of WHO Halfdan Mahler referred to surgery's "proper role in bringing the people of the world nearer to the goal of health for all".[60] Nearly 30 years later, improvement of surgical capacity at the district hospital level was identified as one of the 30 top mechanisms for advancement of global welfare,

and particularly the welfare of developing countries, in the problem category of disease at the 2009 Copenhagen Consensus.[61] The integration of surgery into district hospitals acts as an enabler, raising the ability to deliver other health-care services.[62] Because of its complexity,[63] delivery of safe surgery and anaesthesia signals the presence of the "staff, stuff, space, and systems" of a responsive health care system.[64] Such a system is capable not only of delivering surgical care, but also of treating a broad range of health challenges, whether it be a child with malnutrition, a mother dying of post-partum haemorrhage, a family injured in a bus collision, or a community faced with an Ebola outbreak. As World Bank president Jim Kim stated in his address at this Commission's inaugural meeting, "surgery is an indivisible, indispensable part of health care".[2]

Surgical conditions—whether cancers, injuries, congenital anomalies, childbirth complications, or infectious disease manifestations—are ubiquitous, growing, and marginalising to those who are afflicted by them. These conditions are financially devastating for individuals and their families, economically damaging for countries, and disproportionately threaten the welfare of the poorest and most vulnerable people in our societies. The arrival of 2015 brings with it a new set of goals for the ensuing two decades, including commitments to UHC, increased investments in health, and a collection of SDGs that aim to end poverty, promote economic growth, and ensure good health for all. The one proposed health-related SDG—to ensure healthy lives and promote wellbeing for all at all ages—will need widespread and equitable delivery of surgery and anaesthesia, the treatment needed for a third of the global burden of disease.[2] Similarly, the World Bank and WHO have targets for UHC of at least 80% coverage of essential health services, and 100% protection from OOP payments for health services, by 2030.[39] In a world where 70% of the population cannot access essential surgical services, and 50% are at risk for catastrophic expenditure should they need surgical care, fulfilment of UHC will need an expansion of surgical and anaesthesia services and a pro-poor approach to the financing of surgical care. Such a scale-up will need immediate mobilisation of domestic and international health financing, and a commitment to surgical services as an integral component of health systems strengthening.

Surgical and anaesthesia care are fundamental for health-care delivery for any country at any level of development. Broad scale-up of quality surgical services will prevent deaths, limit disability, palliate suffering, promote economic growth, and help achieve maximum gains in health, welfare, and development for all.

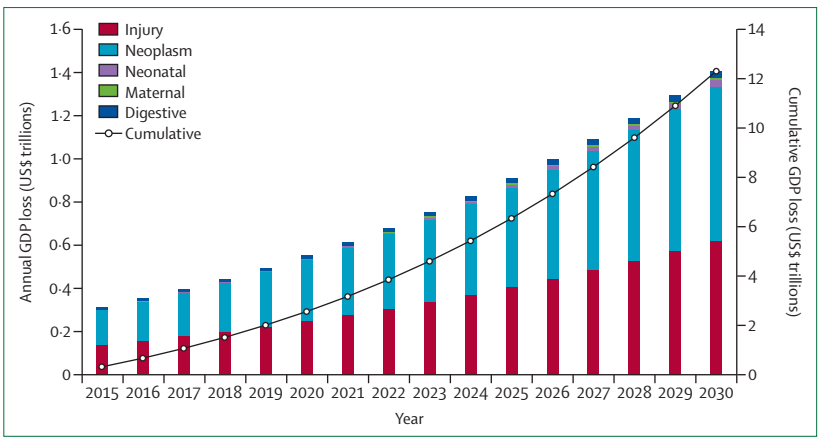



*Figure 4:* **Annual and cumulative GDP lost in low-income and middle-income countries from five categories of surgical conditions (2010 US$, purchasing power parity)**[57]
Data are based on WHO's Projecting the Economic Cost of Ill-Health (EPIC) model (2010 US$, purchasing power parity). GDP=gross domestic product.

## Health-care delivery and management

### The surgical system

A common yet erroneous perception is that the surgical system consists of a surgeon and an anaesthetist in a sterile environment. However, a more accurate perspective acknowledges an interdependent network of individuals and institutions all essential to the delivery of safe, timely, and affordable surgical and anaesthesia care (figure 5). Many of these components are not standalone requirements for a surgical system, but rather for a shared delivery infrastructure that is the basis of a functional health system.[65] A blood bank, for example, is equally important for a woman with post-partum haemorrhage as it is for a child with severe malaria. The goals of achieving a functional health system and surgical system are not separate.

Surgical care begins in the community. Community health workers connect patients in remote areas to providers. They refer surgical patients to the first-level hospital, and provide post-discharge follow-up. First-level hospitals provide the hub for surgical and anaesthesia care, and should be capable of providing most emergent and planned procedures. Tertiary centres can provide specialised care, and serve as hubs for training, research, and system-wide quality improvement.

In most areas, delivery of surgical services consists of a mix between public and private providers.[66,67] Private providers consist of all actors outside the government and can take on many forms, including for-profit providers, not-for-profit providers (eg, non-governmental organisations [NGOs] and faith-based organisations), and informal providers (eg, traditional healers). In some countries, the private sector is responsible for most hospital-based service delivery.[67] All hospitals should connect to the community and to each other through a reliable referral system. Strong clinical leadership, professional management, and government policies should support all levels of care.

In this section we discuss surgical and anaesthesia care delivery at the first-level hospital through the lens of the Three Delays framework often used in the maternal

For **key findings from the health-care delivery and management working group** see appendix p 16

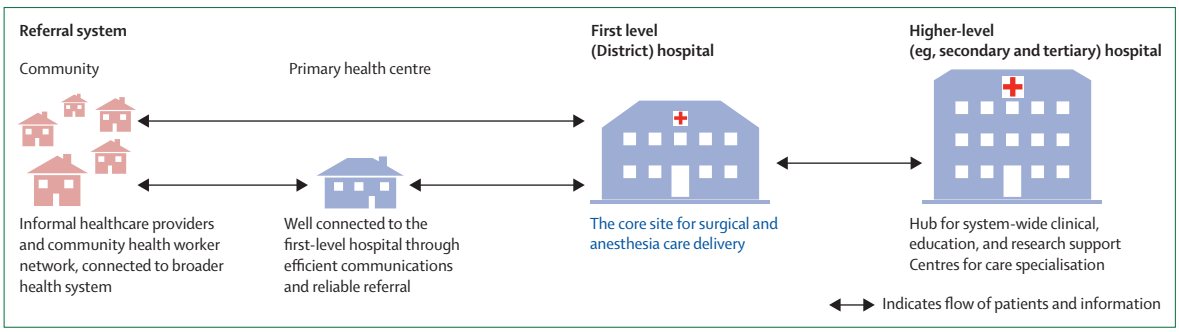



***Figure 5:*** **The surgical system**
The surgical system is an interdependent network of individuals and institutions that reside within the health system.

health community.[68] We outline the role of tertiary care structures and of leadership across the surgical system, focusing on the instruments and systems needed for the workforce to deliver care. We have queried hundreds of providers in resource-poor settings through in-person interviews and telephone conversations, a survey, and electronic correspondence (appendix pp 47–49). We also used the WHO Emergency and Essential Surgical Care Situational Analysis Tool (SAT) database, a collection of 1357 facility surveys (as of April, 2014) from 54 countries collected since 2007 (appendix p 30). This section presents published work and previously unpublished data on present challenges and potential solutions for care provision in low-resource settings.

## The present situation

### *The Three Delays framework*

The ability to receive surgical care when needed depends both on the accessibility of surgical facilities and the availability of surgical and anaesthetic providers to deliver that care. A woman who lives hours away from the nearest hospital probably does not have access to timely surgery and anaesthesia. A woman who lives just minutes away from a hospital that does not have enough surgeons and anaesthetists available to offer care also does not have access to surgery and anaesthesia. Accessibility and availability, then, are crucial concepts in low-resource settings and can be further interrogated under the lens of the Three Delays framework to explain the delay between symptom onset and receipt of appropriate care.[68]

The First Delay—the delay in seeking care—occurs when patients often wait to seek health care because of financial and geographic restrictions, cultural beliefs, poor education, a history of being disconnected from formal health systems, and low awareness of available services or low confidence in those services.[69] Patients turn to informal providers (traditional healers) because they are accessible, trusted, and inexpensive.[70] WHO reports that up to 80% of the population in low-resource settings relies on informal providers who are often poorly connected to the broader health system.[71] This option can lead to further delay in surgical referral.

The Second Delay—the delay in reaching care—occurs when hospitals with surgical capacity are scarce, meaning the nearest facility can be hours to days away, depending on mode of transportation. Few patients have access to private vehicles, ambulance systems are rare, and public transportation is variable in availability.[72] Poverty also plays a strong part, reducing the affordability of public transportation if any is available. We have analysed the distance to surgical and anaesthesia care using the WHO SAT database, and present the median distances patients travel to their nearest surgical facility in various income settings (figure 6).

The Third Delay—the delay in receiving care—occurs when attendance at a hospital does not guarantee treatment, since few first-level hospitals can provide comprehensive emergent operative care. Data from the WHO SAT database show the proportion of first-level hospitals that could provide a caesarean delivery (64%), laparotomy (58%), and treatment for an open fracture (40%). Country-specific studies had similar findings (appendix p 50).

### *Reasons for delays in receiving care*

Structural deficits trouble hospitals in low-resource settings. The WHO SAT database surveyed almost 800 facilities in low-income countries to discover what proportion of them did not have reliable electricity (31%), running water (22%), oxygen (24%), a dedicated area for emergency care (31%), and provisions for postoperative care (47%; appendix p 30). Few facilities, especially rural ones, have access to a computer or the internet; this restriction furthers a sense of isolation and prevents access to up-to-date clinical and research resources.[73] 55% of district hospitals surveyed across eight African countries did not have an anaesthesia machine.[74] About 70% of operating rooms in parts of sub-Saharan Africa had no pulse oximeter.[8] Of 28 district hospitals in Zambia, 35% did not have a laryngoscope.[75] A study in Nigeria reported that only 42% of district and 24% of regional hospitals had supplies to maintain a paediatric airway.[76]

Essential medications, supplies, and personal protective equipment are frequently out of stock.[74,77] Stock-outs are often the result of insufficient funding and poor

administrative management of inventory.[78,79] Disposables are often reused (appendix p 47).

In low-resource hospitals, equipment often does not work and is difficult to repair (appendix p 49).[80] Most equipment is foreign—WHO once estimated that up to 80% is donated—so local serviceability is unusual, and manufacturers seldom extend maintenance contracts for old equipment.[81] Assessments show that almost 40% of donated equipment is out of service.[82] Hospitals often feel obligated to accept donations even when the equipment or supplies are not useful.[81]

WHO estimates that more than half of the world does not have access to radiology services.[83] Only 41% of first-level hospitals studied in Nigeria and 63% of hospitals studied in Botswana had a radiograph machine (appendix p 36).[84] Pathology services are essential for surgical treatment, yet few first-level hospitals have the ability to preserve a sample or obtain a pathological diagnosis.[85] Basic blood laboratory and microbiology services are also variable in availability.[86]

The absence of a safe blood supply is a crucial problem worldwide. Blood donation rates are low because of a high prevalence of anaemia and transfusion transmissible illnesses (TTIs), and poor blood collection infrastructure.[87,88] Only 27% of hospitals in low-income countries reported an on-site blood bank (appendix p 51). The few facilities that have an on-site blood bank are concentrated in urban areas. Safety is also a concern: despite high rates of TTIs, 39 countries report that donated blood is not routinely tested and a third of 98 reporting countries had stock-outs of test kits.[89]

Many providers resort to unbanked direct blood transfusion, in which a family member or community member donates on the spot, blood is tested with a rapid test kit that includes cross-match, and the patient is immediately transfused (appendix p 51). This process carries increased risk of TTI, and both paid and unpaid donors can face coercion.[90]

In the face of minimally functional first-level hospitals, the burden of care falls on functional non-governmental and tertiary hospitals. Tertiary hospitals are overcrowded; some exceed capacity by 200–300% (appendix p 47). In high-income settings, the association between overcrowding and adverse events is well documented.[91] Tertiary centres, burdened with acute surgical volume from first-level hospitals, lose the ability to offer more complex, planned surgery.[92] Planned surgery, often referred to as elective in the high-income setting, is seldom elective in LMICs. These non-elective chronic, debilitating surgical conditions, left untreated for years, have generated a tremendous backlog.[93]

Insufficient managerial support leads to little focus on processes and protocols in all areas.[94] Poor surgical functionality is often attributed to an absence of resources, but once resources are obtained, the hospital's functionality depends on organisation to bring those resources together successfully.[95] Too often, managerial tasks are left to clinicians with substantial clinical responsibilities and little training in professional management.[96]

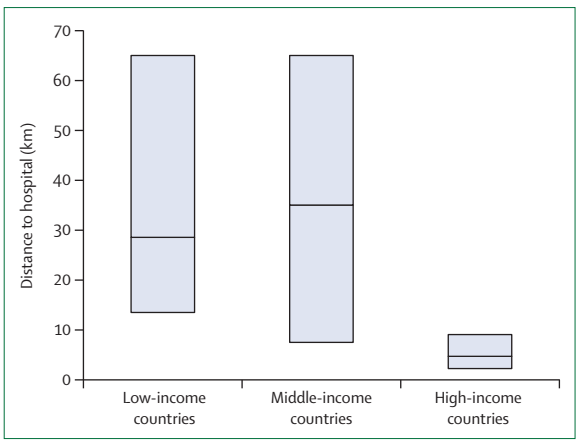



***Figure 6:*** **Median distance to a hospital according to country income level**
Data are medians and IQRs of the estimated distances patients travel to reach a hospital in low-income, middle-income, and high-income countries. Low-income and middle-income country data are from the WHO Emergency and Essential Surgical Care Situational Analysis Tool database, 2007–14 (appendix p 30). Due to paucity of data for high-income countries, we substituted the data from the WHO Situational Analysis Tool database with US data from the Centers for Disease Control and Prevention's National Center for Health Statistics Research Data Center, 1999–2009.

For more on the **CDC's Research Data Center** see www.cdc.gov/rdc/

Leadership is often diffuse and goals are unclear or set by an external agency, restricting autonomy at the local level.[94,97] Poor structural hierarchies make it difficult to reprimand the habitually late surgeon or identify the root cause of an improperly cleaned instrument making it into the operating room. Insufficient administrative support further hinders mundane tasks such as filing paperwork to replace a broken ultrasound machine (appendix).

Additionally, referrals are a source of consternation for both the referring and accepting parties, not to mention the patient who bears the cost of transportation. Patients are transferred because of inadequate capabilities at the local level, but capability at the next level is not guaranteed, which reinforces the adage that referral is a myth.[98]

Furthermore, more than 80% of people in low-income countries might have been subject to some type of corruption related to health care.[99] Corruption can manifest as bribes for necessary health-care tasks or more subtly in priority setting by ministries of health, infrastructure allocations, and hiring decisions.[100] People in authority positions often have the means to leave the country for care, lowering their incentive to invest in strong health systems for people with the lowest income. Restricted freedom of the press to report present circumstances without retribution exacerbates existing deficits.[99]

More than 300 international NGOs provide surgical services in LMICs.[101] Although most of these NGOs

provide excellent care, owing to uneven power dynamics, a discord often exists between the services most needed and the services that can be provided.[102,103] When more than one NGO delivers similar services, mistrust and direct competition occurs. All combined, this discord can lead to dysfunction and poor integration with the health system. Short-term visiting teams can draw away resources from the local providers who deliver continuous care, create a perception within the community that visiting teams provide higher-quality care, and introduce uncertainty as to the availability of a service.[104] Nonetheless, an offer for a clinical service not usually provided is difficult for low-resource institutions to refuse.

## The way forward

### *Reduce the First and Second Delays*

A strong prehospital network, which includes primary care centres and rapid-response ambulances, could partly overcome delays that patients can incur while seeking and reaching care.[105] However, a comprehensive and more immediate approach needs context-specific interventions that engage the community and existing providers.[106]

Surgical teams should engage all members of the surgical ecosystem, including informal providers and community health workers, particularly in areas without formal health-care facilities. A comparative model is the integration of traditional birth attendants into the maternal health system to refer critical cases to first-level hospitals.[107] Community health workers have already been effectively used in many large-scale programmes, from Haiti to Ethiopia, with documented improvements in health outcomes.[103,108] BRAC, a Bangladeshi NGO, has devised a low-cost referral system for obstetric care that uses community health workers and traditional birth attendants with mobile technology to systematically reduce First and Second Delays (appendix p 21). This partnership enables BRAC community health workers to identify complicated deliveries, and coordinate reliable, timely transportation to a hospital.

Community participation is already the default for emergency transportation in many low-resource settings, and these ties should be strengthened while more formal systems develop.[109] So-called Good Samaritan laws that protect first-response volunteers from legal prosecution can ease barriers to trauma-victim response.[110] In Ghana, truck drivers who brought trauma victims to the hospital were compensated through a fund established for this reason.[111] In Uganda, community-based trauma response programmes have trained individuals most likely to be near accident scenes (eg, taxi-drivers and city police) in basic first-response techniques.[112] Similar programmes have shown promise in Ghana, Cambodia, Madagascar, Israel, India, Iraq, and Iran (appendix p 22).

Lastly, when geographic challenges are immense, an alternative approach is to bring care to the patient. Cinterandes Foundation, an Ecuadorian NGO founded in 1990, uses a 7 m truck with a mounted operating room to take surgical and anaesthesia care to patients in the country's mountainous regions (appendix) p 22. Similar approaches have been used effectively in other specialities—eg, in radiology screening.[83]

The risk of being left destitute as a result of medical care, however, is a real possibility for most people with a low income, and will continue to hinder efforts to reduce the First and Second Delays.[28] OOP expenses combined with transportation and food costs drive millions who seek care further into poverty each year and would do so to billions more if they tried (discussed in detail in the Economics and financing section).

### *Reduce the Third Delay*

On reaching the first-level hospital, the patient should have a reasonable guarantee of treatment. The first-level hospital is closest to its catchment population and should serve as the core delivery site for surgical care.[54] In fact, sufficiently equipped and staffed, it should be able to provide about 80–90% of surgical procedures, including treatments for acute abdomen, obstetric complications, and open fractures (appendix p 77). We believe that provision of laparotomy, caesarean delivery, and treatment of open fracture are bellwethers of a system functioning at a level of complexity advanced enough to do most other surgical procedures. Hence, we refer to them as the Bellwether Procedures. The WHO SAT database was used to interrogate this notion, and these three procedures proved to be indicators for completion of most other elective and emergency procedures in WHO's primary surgery package (appendix p 30). Further, the completion of each individual Bellwether Procedure correlated with the completion of related, less complex procedures from the SAT database (figure 7).

The Third Delay will shorten when first-level hospitals can efficiently deliver a broad range of surgical and anaesthesia services. Borrowing from the quality-improvement literature, we will use a structure, processes, and outcomes framework to discuss needed improvements in care delivery.[113]

#### *Structural and resource needs*

Although surgeons from across the world have derived ingenious workarounds to infrastructure deficits (eg, rainwater collection reservoirs and use of solar power), the need for creativity in basic infrastructure is an additional burden to the heroic clinicians committed to low-resource populations.[114] Official investments should be directed towards all of the basic needs of the health system, from electricity and water to radiograph machines and drugs, aiming for a well distributed shared-delivery infrastructure.[65]

Many organisations have attempted to characterise specific methods, equipment, and drug needs for surgical and anaesthesia care, and these are summarised in the appendix (p 27). We are reluctant to endorse any specific

list, as needs change with time and between contexts. Further, although all agree that safety in surgical and anaesthesia care is important, fewer agree on what actually constitutes safe or quality surgery. Adverse events exist even in the world's highest-resource systems, and what constitutes 'quality' is challenging to define.[117] To blindly pursue the perceived high-income country (HIC) safer option without an evidence base to support it can be a dangerous endeavour; many practices that make life-saving care possible in low-resource settings might be mischaracterised as unsafe. The pressure-cooker used for sterilisation in a rural Indian first-level hospital might be just as effective as the industrial-grade autoclave in the tertiary centre. In fact, these cost-conscious adaptations from the low-resource environment might be important cost-saving innovations in the high-resource setting. Without further research, uncertainty will persist. With this in mind, we came to consensus on general needs for safe surgery on the basis of a review of the existing academic and grey literature and expert panel deliberation, avoiding an overly prescriptive set of recommendations based on scant evidence (panel 2).[117]

The Bellwether Procedures need skills that span general and orthopaedic surgery, obstetrics, and anaesthesia. Workforce shortages, however, make it unlikely to have a general surgeon, orthopaedist, obstetrician, and anaesthetist available in all first-level hospitals, all the time.[118] As such, providers who practice in these environments are forced to transcend contextually irrelevant professional constructs and command a broad skillset. These true generalists are actually multispecialists, and allow care provision for many rural communities that would otherwise go without. However, to work as a multispecialist in a rural setting is taxing, both personally and professionally. Away from friends and family, working in remote areas in poorly equipped hospitals, treating high-acuity patients with minimal resources, with few opportunities for professional development, restricted interactions with peers, and little recognition of their sacrifice can lead to a sense of isolation and futility.

Maintenance of a motivated workforce in low-resource environments, however, is essential for service provision, and ministries of health and professional societies should take active steps to ensure these clinicians are celebrated instead of neglected.[119] To ensure that providers have the necessary instruments to practise is imperative, as are opportunities for continuing education and professional development. These resources include access to the internet, online clinical management

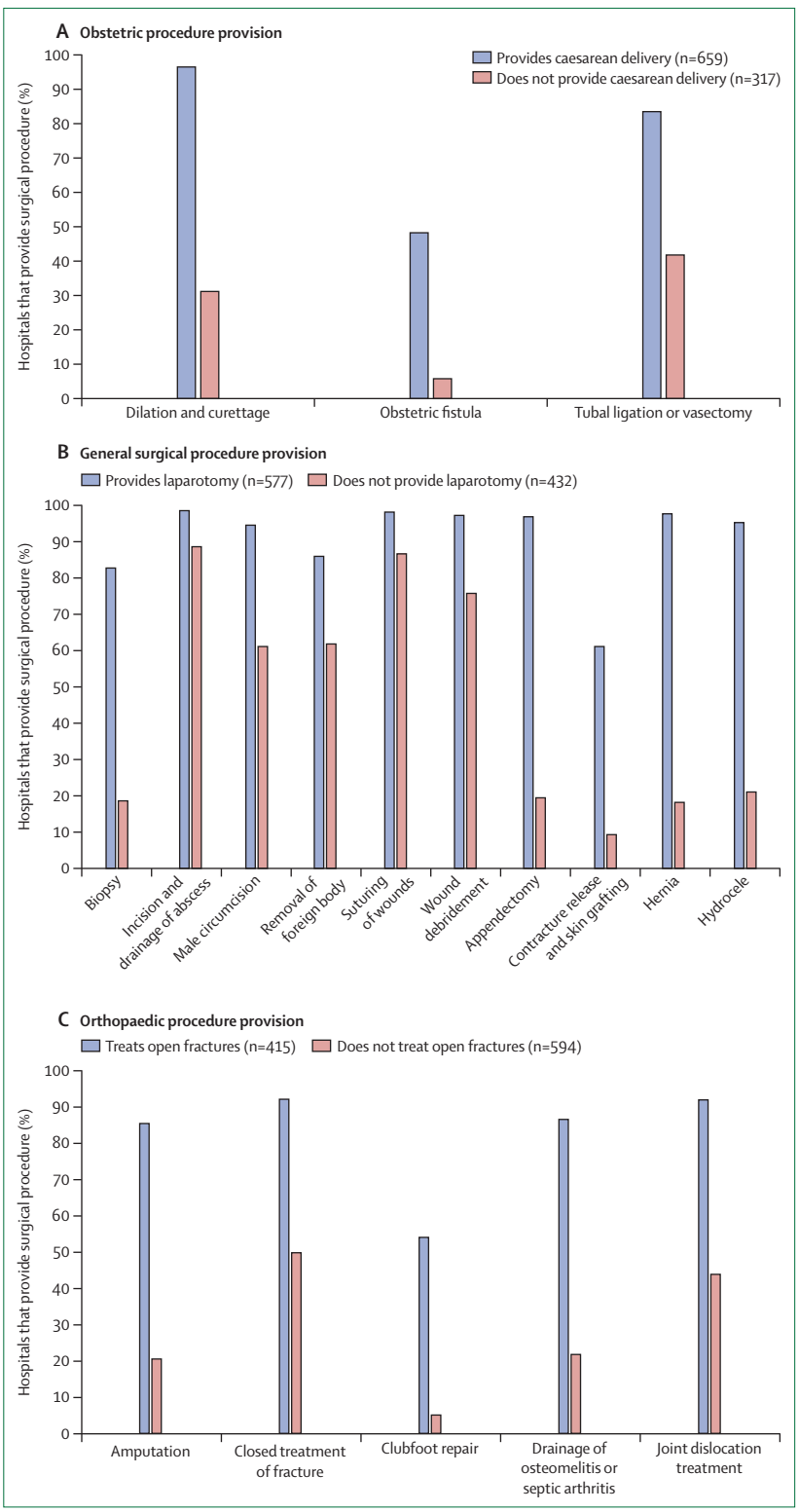



***Figure 7:*** **Proportion of surgical facilities that provide listed surgical procedure according to provision of related Bellwether Procedure**
(A) Proportion of surgical facilities in LMICs that provide the listed obstetric procedures according to whether or not they also provide caesarean delivery. (B) Proportion of surgical facilities that provide the listed general surgical procedures according to whether or not they also provide laparotomy. Data are from the WHO Emergency and Essential Surgical Care Situational Analysis Tool database, 2007–14 (appendix p 30). (C) Proportion of surgical facilities that provide the listed orthopaedic procedures according to whether or not they also treat open fractures. LMICs=low-income and middle-income countries.

***Panel 2*: Ten needs for the provision of safe surgical and anaesthesia care**

1. Trained surgical provider
2. Trained anaesthesia provider
3. Infrastructure, equipment and supplies necessary to perform safe general anaesthesia, loco-regional anaesthesia, laparotomy, caesarean delivery, and treatment of open fracture (including, for example, electricity, water, personal protective equipment for staff, basic laboratories, and HIV-testing capabilities)
4. Decontamination and sterilisation capacity
5. Blood supply that is safe and affordable (screened and cross-matched blood)
6. Drugs, including antibiotics, pain medicines, and anaesthetics (from the WHO Model List of Essential Medicines)[116]
7. Nursing care, which includes a record of appropriate physiological observations
8. 24 h surgical cover with the ability to review and respond to a deteriorating patient
9. Quality-improvement processes, including audit of perioperative mortality
10. Risk assessment and operation planning for planned procedures

resources, textbooks, and research literature.[120] Pathways for the training of supporting staff, such as task-shared providers, might provide hope for a more reasonable workload. Establishment of rotations for surgical residents through first-level and other low-resource hospitals not only recognises the crucial role that multispecialists can serve in resident training, but also connects them to tertiary centres.

Augmentation and equitable distribution of the blood supply is essential. Blood donation rates can vary substantially, and although no gold standard exists, most high-functioning health systems with high life expectancy achieve a rate of at least 15 donations per 1000 population (appendix p 51). In the long term, the reduction of chronic anaemia and TTIs will be important to ensure a robust donor pool.[89] In the short term, workarounds like unbanked direct blood transfusion should be optimised for safety with provider training and delivery of rapid testing kits. Tranexamic acid effectively reduces the need for blood transfusion and its supply and use should be encouraged.[121] Finally, the blood banking infrastructure should be well distributed for collection, storage, and delivery.

Ultrasound is important to the first-level surgical hospital. It provides the capacity for a broad range of rapid diagnoses, including those for fractures, ectopic pregnancies, and ruptured solid organs.[122,123] Low-cost innovation will be important to make imaging technology such as ultrasound and CT scan, which are so crucial to clinical decision making, available to more of the global population (panel 3). Strategies to leverage connectivity to compensate for the shortfall of radiologists and minimise maintenance costs will be important. The global radiology community continues to make strides towards technologies that allow remote image interpretation despite restricted bandwidth, network disruption, and electrical grid restrictions.[84]

The greatest gains in spreading the reach of pathology might be realised by improvement of services at regional and tertiary centres, and improvement of connectivity between the tertiary and first-level centres. Professional collaborations consisting of training support between areas with an excess of pathologists to areas with a deficit will be crucial to improving services at higher-level centres.[85,133]

Maintenance is imperative to address the common concerns of equipment failure. The availability of local service contracts should be a guiding principle during the procurement process. Corporate responsibility among manufacturers who sell to low-resource areas should include contracts that transcend the traditional, high-income standards of obsolescence. Reliable maintenance, however, cannot be sustained without programmes to increase capacity of biomedical equipment training (BMET).[124,125] Corporate partnerships with academic institutions and local collaborators to establish BMET-certification programmes, like the General Electric Foundation's programme described in the appendix (p 24), can be valuable to develop this cadre of workers.

WHO has outlined some general guidelines for the donation of equipment and supplies.[81] Three points should be emphasised. First, donations should be demand-driven, directly related to the specific needs of the receiving institution. Second, donated equipment should be matched with a plan for long-term maintenance.[125] If partners cannot provide the specified equipment with maintenance, they should instead consider contribution to infrastructural investments, maintenance contracts, or training. Finally, donation of consumables should be discouraged, as they complicate supply chain information flow and rarely provide long-lasting benefit to the receiving institution.[134]

*Processes to improve care delivery*

Management practices and capacity are strong drivers of volume and quality in the high-income environment. Management might be even more important in settings in which maximal use of the few resources available is a practical necessity. Professional health-care management, consisting of either clinicians or non-clinicians with management training, is needed to focus on hospital performance, process optimisation, cost savings, and quality, and to provide administrative support.[135] Hospital leadership should consist of clinical leaders and professional managers. These leaders should be enabled to develop autonomous strategies to meet performance and financial targets, create employee buy-in, and cultivate a shared sense of purpose in staff. Accountability is necessary and leadership should be enabled to define its own organisational structure, complete with the ability to recruit, promote, demote, or terminate employees on the basis of transparent criteria.

Health-care managers do not add value merely by reducing costs; hospital efficiency should not be mistaken as a singular aim. The greatest health and

economic gains will be realised with true, meaningful reductions in the burden of disease. As such, true value is added only when cost reductions are linked inextricably to the goal of providing necessary care to more patients, at low cost to the health system and to the patient. Discharging a patient early might save the hospital in the short-run, but if early discharges incur high indirect follow-up costs for patients, they have not served their aim. Similarly, investment in personnel to assist patients, often illiterate, to navigate a complex medical institution might cost the hospital in the short term, but can ensure patients actually receive care.[129] Ministries of health should ensure that incentives for hospital management and clinical leadership align with the goal of efficient, system-wide reductions in the burden of disease.

Process standardisation can be a low-cost driver of efficiency, quality, and safety.[136] One example is WHO's Safe Surgery Checklist, which showed that adverse events in low-resource settings could be reduced through a simple method for communication, if a minimally functional surgical system is in place.[137,138] Most hospitals can benefit from process standardisation, and organisations with relevant guidelines for low-resource settings should make them publicly available, perhaps through a registry hosted by WHO or other international collaborators. Health-care managers can work with clinicians to identify relevant protocols and help adoption according to local context.

Reliable supply chains are crucial. Consumable shortages are often due to inadequate information and poor management. These issues can be countered with the standards of supply chain management, but application of these standards would need upfront investments to ensure future savings.[139] Too many surgical units run as close to or below the minimum necessary units of resources, making them ultimately unreliable. With investments in warehousing and information management, health-care managers can focus on optimisation of efficient, bidirectional information flow, on the basis of usage patterns with built-in redundancy (eg, at least 3 months of buffer at the site of delivery).[139]

Streamlining of procurement decisions might also be prudent. For example, restriction of suture orders to a standardised set according to clinical consensus instead of ordering on the basis of individual surgeon preference might yield cost savings (appendix p 47).

Centralised negotiation of framework purchasing agreements with decentralised ordering is an efficient way to procure consumables at the lowest price while allowing flexibility in shifting demands during service scale-up.[140] Chile, Mexico, and the various UN programmes are good examples of the use of strong framework agreements to drive purchasing.[140]

Improved referral between facilities depends on many factors already discussed, including financial resources, transportation infrastructure, and staffing. Communication can be improved, though, through development of protocols that establish clear transfer criteria and an understanding of what can be done for the patient at both ends.[141] Ministries of health can help develop these protocols through committees that include clinicians and health-care managers from all

### *Panel 3*: Opportunities for innovation

**Surgical device consortium**

Transplantation of equipment designed for high-income settings into low-income ones is insufficient. Similar to other industries, however, medical equipment manufacturers find it challenging to develop profitable products for low-resource settings. Equipment in low-resource countries needs to be affordable and yet durable to withstand erratic electricity, infrequent maintenance, and harsh environments.[124]

However, encouraging examples of surgical innovations developed for low-resource settings exist. Lifebox is an organisation that has sourced low-cost pulse oximeters to hospitals in more than 90 low-income and middle-income countries. Durable pulse oximeters specifically designed for low-income operating rooms are manufactured in Taiwan (for US$250) and supplied with training materials, the WHO Surgical Safety Checklist, and accompanied by training courses for providers in countries with large distribution programmes. The Universal Anaesthesia Machine (Gradian Health Systems, New York, NY, USA) and Glostavent (Diamedica, Barnstaple, UK, are examples of anaesthesia machines that are low-cost, designed to operate despite abrupt power outages, easy to maintain, and accompanied by long-term service contracts and commitments to train local biomedical equipment technicians.[125]

An international device consortium could have a strong effect in driving forward innovation for low-resource areas. It would include a partnership between the private and public sector, and would follow the Drugs for Neglected Disease Initiative, a similar collaborative that has had success with the development of pharmaceuticals for disorders that largely effect the world's poorest people. Ideally, such a consortium would also be able to bring to scale the vast amount of low-cost innovation that takes place everyday in hospitals worldwide. When providers are forced to improvise due to resource restrictions, the results can be impressive; the work of rural surgeons from Nigeria and India are just a couple of examples.[114,126]

**Surgical mobile health consortium**

Mobile health (m-Health) tools have been implemented in various global health contexts.[127,128] These technologies have also been used in surgical care. In Haiti, photographs taken by a community health worker's smartphone have been used to assess postoperative surgical wounds.[129] In Kenya, Tanzania, and elsewhere, mobile money services have been used to reimburse transportation costs for patients who need surgery but do not have bank accounts.[130]

Unfortunately, too many valuable applications do not last beyond the initial pilot project because of poor planning for scale-up, poor local buy-in, and minimum budgeting for monitoring and assessment.[131] As such, resources are wasted in reinventing a product from the bottom up in other settings rather than building on previous efforts, and local buy-in is squandered on cumbersome projects with little follow-up.

Botswana is a country where the Ministry of Health has invested in systematic scale-up of promising m-Health applications, from cervical cancer screening to radiology.[132] We propose a similar, but international effort, led by a consortium on surgical m-Health, to bring together the public and private sectors, funders, developers, and NGOs to promote development of value-additive applications and coordinate well designed assessments of effect. Applications that clearly show value and scalability to other contexts can be supported on an internationally visible platform; lessons learned from unsuccessful projects can be catalogued.

For more on **Lifebox** see http://www.lifebox.org/about-lifebox/

For more on the **Drugs for Neglected Disease Initiative** see www.dndi.org

levels of care, including public, private, and NGO stakeholders.[142] These committees should work to minimise or eliminate the cost of transfer to the patient.

Equipped with basic infrastructure and administrative and managerial support, first-level hospitals should aim to offer a broad range of surgical procedures. Consistent provision of planned surgery needs only a marginal increase in resources above those already in place for emergency care. In fact, provision of planned surgery can confer valuable benefits to the function of the surgical team, including morale, confidence, and efficiency; patients can be preselected, health status optimised, and teams can focus on timely starts and process checks.[143]

Ministries of health should ensure that planned surgical care is available at first-level hospitals, consistent with population needs. Ideally, these procedures can be stratified by volume and risk, and the initial focus can be on provision of high-volume, low-risk planned procedures at first-level hospitals, referring the rest to tertiary centres. In many instances, owing to resource constraints of the health system and of the patient, first-level providers do not have the option of referral to a higher-level centre, and should do their best to provide the necessary medical attention. Nonetheless, figure 8 outlines some common procedures stratified in a must do, should do, and can do framework for first-level care. The framework serves as an example, is not comprehensive, and should be adapted to different contexts according to relevant disease burden. NGOs and volunteer teams can be particularly useful in the provision of support for planned surgical care.

*Outcomes and other opportunities*

The ultimate goal is to build a strong, resilient surgical system that can provide consistent, high-quality care. Armed with adequate structures and improved processes, a great opportunity to improve outcomes in low-resource settings exists. As structural and functional capacity at first-level hospitals improves, higher-level hospitals can serve as hubs for education, research, and clinical support. Improved network connectivity between the tertiary hospital and its health system partners will allow for novel collaborations. As discussed, providers at first-level hospitals often feel isolated, and have few opportunities for interprofessional interaction. A system-wide morbidity and mortality conference, hosted by the tertiary centre over mobile link, for example, could connect staff at remote first-level hospitals into a forum for multilateral learning. A collaborative approach between a tertiary centre and rural hospitals has been fostered by the Christian Medical College in Vellore, India, which has a longstanding practice of encouraging its surgical graduates to practise in rural communities.[144] These surgeons are paired with colleagues at the tertiary centre, who are available by phone to provide support for challenging cases or discuss the need for referral.

Higher-level centres can also serve as the clinical support hub for complex radiology, pathology, and services with needs unavailable at the first-level hospital. A reliable system to transfer films and pathology specimens and return diagnostic reports should be established.

Research is important to improve outcomes; adherence to protocols should be measured, metrics tracked, and adverse events openly reviewed.[94] Much of this activity will hinge on having the staff and the tools for research, and although excellent clinical care can be provided in the absence of electronic medical records, context-appropriate information systems can enhance both data collection and process monitoring. Research collaborations between well resourced academic institutions with research skills and clinicians in low-resource settings with high clinical loads and important research questions can be a powerful aspect of global health partnerships.

Clinical conditions with management guidelines based on the high-income context present a challenge to clinicians in low-resource settings, who might feel vulnerable when resource constraints force clinical decisions that are different from contextually irrelevant, but published, protocols. Academic and professional entities within low-resource settings should take the lead in research and establishment of relevant clinical practice guidelines. The appendix lists some examples of protocols developed for use in low-resource settings (appendix p 24).

While surgical capacity is developed, local and international NGOs can play an important part in care delivery. When using a measured approach consistent with the local needs, culture, and context, NGOs can strengthen the system by assisting local clinicians to tackle the backlog of unmet need, integrating with local training programmes, and enhancing local

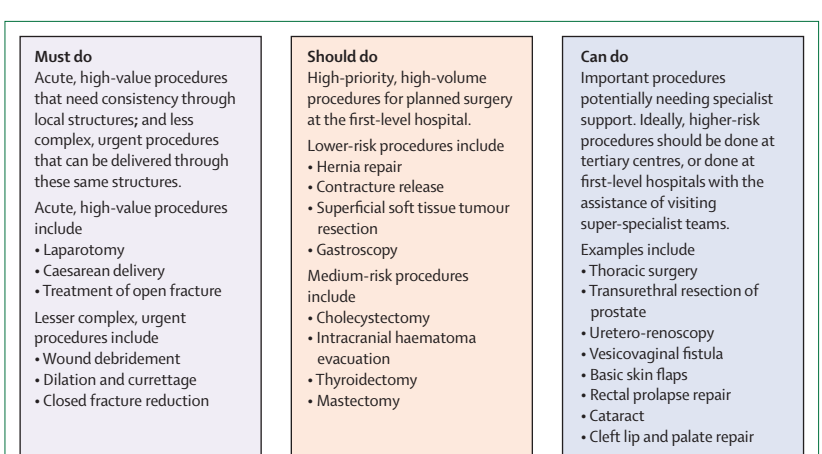



*Figure 8:* **Common surgical procedures stratified in a must do, should do, and can do framework for first-level care**
This chart should be adapted to local context.

infrastructure.[145] We propose an expansion of coordinated, demand-driven international surgical support aimed to address the unmet burden of surgical disease. This support could consist of long-term postings of surgical staff to high-need areas, like Operation Smile's Comprehensive Cleft Care Centres (appendix p 25), or many sequential short-term commitments that add up to a consistent, predictable presence. Academic and professional societies can help coordinate global surgical volunteerism with a centralised registry to help uninterrupted service. The Royal Australasian College of Surgeons' Pacific Islands Program is an example of one such enterprise (appendix p 25).[146]

Corruption at the point-of-care is a challenging problem with no easy solutions. Establishment of community-based monitoring boards, consisting of community leaders and hospital officials, is a practical measure directed towards the point of care. These boards can provide the community with a formalised grievance process with transparent feedback loops that report to hospital leadership and government bodies. This process has been effective in rural India, and can help promote community trust and confidence in the health system.[147] Elimination of corruption on a national level might also help. Rwanda and Georgia are examples of countries previously labelled as corrupt that have made impressive strides through an independent media, legal frameworks with protections for whistle-blowers, aggressive prosecution of corrupt activities, and improved documentation through electronic records.[148]

### Recommendations for health-care delivery and management

*National (hospitals, ministries of health)*

- Culturally appropriate outreach to the community and existing health networks is essential to promote health system use.
- Comprehensive prehospital referral systems can be developed at low cost, leveraging community health workers and mobile connectivity.
- All first-level hospitals should aim to provide the Bellwether Procedures (which we define as laparotomy, caesarean delivery, and treatment of open fracture) because these are acute, high-value procedures and because their consistent provision is suggestive of functional surgical systems with broad service delivery.
- Professional health-care managers, both clinicians and non-clinicians with management training, should be prioritised and empowered to improve access, efficiency, and safety.
- Tertiary hospitals should have a key role as the system's education, clinical support, and research hub.
- A national blood donation strategy should be developed to achieve blood donations of at least 15 donations per 1000 population and equitable distribution of blood bank infrastructure.
- Centralised framework purchasing agreements with decentralised ordering and supply chain management should be used to allow hospital facilities to order per local needs.

*International (WHO, NGOs, professional societies, industry)*

- Clinical guidelines and protocols relevant to the low-resource setting should be established and shared publicly by institutions in developing countries.
- All donated equipment should be accompanied by long-term maintenance contracts or should be replaced with funds for other local investments.
- International professional societies, high-income academic medical centres, and NGOs play an important part in the coordination of short-term interventions and support; this participation should be within the framework of long-term, demand-driven commitments focused on system strengthening.
- International consortiums consisting of public–private partnerships can drive forward innovation and scale-up in the areas of medical devices, biomedical equipment training, and mobile health applications.

## Workforce, training, and education

For **key findings from the workforce, training, and education working group** see appendix p 107

### Human resources for health in surgery and anaesthesia

Human resources are the backbone of health-care delivery systems. At present, major shortages worldwide in the surgical workforce compounded by maldistribution of the existing workforce both within and between countries result in gross inequity.

LMICs are disproportionately affected by low surgical workforce density. Within these countries, people living in rural areas, those with a low income, and those who are marginalised are the most affected by these shortages (appendix p 13).[34] Despite these challenges, surgical and anaesthetic providers endeavour to provide care for people who need it.

### The present situation

*The surgical workforce*

The health workforce involved in the delivery of surgical and anaesthesia care consists of an interdependent network of clinical and non-clinical professionals involved in health-care delivery, management, training, and monitoring.[149] This network includes, but is not restricted to, community health workers, hospital managers, theatre technicians, surgeons, anaesthesiologists and obstetricians (all of whom might be trained or still be in training), generalist physicians and associate clinicians providing surgical and anaesthesia care, educators, rehabilitation specialists, and diagnosticians in laboratory, pathology, and radiology science (appendix p 108). We acknowledge the interdependency of members of the surgical workforce, but for the purpose of the Commission, our report will focus on a narrow yet crucial element of the workforce: surgical, anaesthetic, and obstetric providers.

In 2006, WHO's World Health Report[149] identified a crucial threshold of 228 skilled health professionals per 100 000 population below which countries were unable to reach essential health targets and were deemed to be in health workforce crisis. Updates describe 83 countries still below this threshold.[150] However, data collected do not address how specialty-specific providers are distributed within each country. This uncertainty has prevented accurate assessment of surgical workforce needs and hampered workforce planning at both national and international levels. To address this, a collaboration between WHO and our Commission was formed to collect information about national numbers of specialist surgeons, anaesthetists, and obstetricians worldwide.[151] Data for other cadres of surgical and anaesthetic providers were not available.

Our estimates from the WHO Global Surgical Workforce database suggest a supply of 1 112 727 (IQR 1 059 158–1 177 912) specialist surgeons, 550 134 (529 008–572 916) specialist anaesthesiologists, and 483 357 (456 093–517 638) specialist obstetricians worldwide.[151] These numbers are not distributed in terms of regional or national population size and need: a fifth of the world's specialist surgeons, a sixth of the world's specialist anaesthesiologists, and a third of the world's specialist obstetricians attend to the poorest half of the world's population. Only 12% of the specialist surgical workforce practise in Africa and southeast Asia, where a third of the world's population lives.[151]

The maldistribution of the specialist surgical workforce, measured by the density of specialist surgeons, anaesthetists, and obstetricians per 100 000 population, correlates with specific health outcomes. We noted that countries with increased densities of providers per 100 000 population have improved maternal survival. For each 10 unit increase in the density of surgeons, anaesthesiologists, and obstetricians, maternal mortality decreases by 13·1% (95% PCI 11·3–14·8). There are particularly steep improvements in maternal survival from 0 to roughly 20 specialist providers per 100 000 population. Beyond densities of 40 per 100 000 population, gains are still present but the gradient of the curve is flatter (figure 9; appendix p 109).[152] Although the number of surgical and anaesthetic providers alone cannot guarantee surgical productivity or quality, the density of specialist surgeons, anaesthetists, and obstetricians does correlate with surgical volume (appendix p 111): these thresholds of 20 and 40 providers per 100 000 correspond with a volume of surgery of 2917 and 5834 procedures per 100 000 population, respectively, and are symmetrically distributed around the estimated global need of 4664 surgical procedures per 100 000 population (appendix p 8, 11).[152]

The workforce densities of 20 and 40 specialist surgeons, anaesthetists, and obstetricians per 100 000 population show the disparities between national health systems and outcomes and might be useful for the measurement and monitoring of progress. Additionally, such surgical workforce densities might serve as trace indicators for strong health systems. These indicators are the first to address the density of the surgical workforce. The surgical workforce densities of 20 per 100 000 population and 40 per 100 000 population will be used throughout the report as a basis for modelling. As with many indicators, the surgical workforce indicators function best when measured in conjunction with other surgical system indicators, to ensure a complete picture of need, and to prevent unbalanced attention to particular areas within a system.

44% of the world's population lives in countries with a specialist surgical workforce density lower than 20 per 100 000 population, and only 28% lives in countries with a specialist surgical workforce density higher than 40 per 100 000 population. Using the higher workforce density of 40 per 100 000 population as an optimum, we estimate that in 2015 there is a worldwide shortage of just more than 1 million specialist surgical, anaesthetic, and obstetric providers in 136 LMICs. Based on UN World Population Prospects to 2030,[153] we estimate an additional 2·28 million specialist surgical, anaesthetic, and obstetric providers are needed worldwide to reach that same density by 2030, even without accounting for migration. To meet this target, the present global surgical workforce would need to double, at a minimum, in just 15 years.[150]

Shortages and maldistributions within the global surgical workforce are also seen within countries. Specialist providers are often concentrated in urban areas, which have more surgical infrastructure and

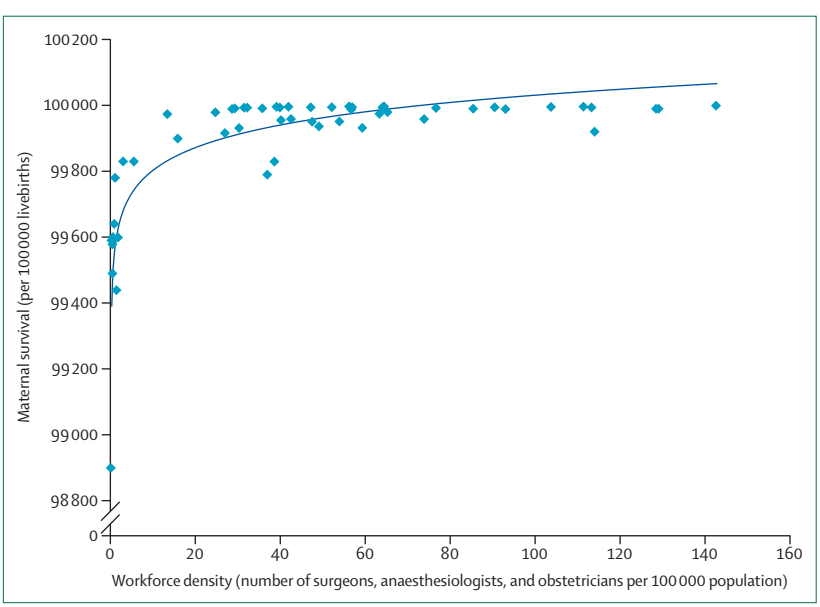



***Figure 9:*** **Specialist surgical workforce density and maternal survival[148]**
A surgical workforce density of less than 20 per 100 000 specialist surgeons, anaesthesiologists, and obstetricians correlates with lower rates of maternal survival. Maternal survival per 100 000 livebirths=98·292 × ln (workforce density) + 99 579.

better-equipped tertiary care centres than do rural areas.[127] For example, 30% of the Sierra Leonean population live more than 2 h driving distance from a specialist surgeon.[155] Even people living in geographic proximity to a specialist surgeon might have restricted access to surgical and anaesthesia care; 45% of the Sierra Leonean population thought to be within timely geographic access of a specialist surgeon are served by only 0·26 surgeons per 100 000 population (appendix p 112).[25] Therefore, 75% of the country have insufficient access to and availability of surgical care.[25]

*Task shifting and task sharing*

Surgical NGOs and visiting teams provide a significant amount of surgical and anaesthesia care in many LMICs to help address those without access to care.[130,156] However, this approach is not sufficient to address all surgical and anaesthesia needs in these countries. Subsequently, a cadre of general practitioners (GPs) and associate clinicians are relied on for surgical and anaesthesia care. In some countries, upwards of 80% of surgical, obstetric, and orthopaedic procedures might be done by associate clinicians in a practice known as task shifting.[157–159]

Task shifting and sharing have been used for decades in both high-income countries and LMICs as a means of quickly and inexpensively expanding access to care.[160–162] The term task shifting, or, as defined by WHO: "the rational redistribution of tasks among health workforce teams…from highly qualified workers to health workers with shorter training and fewer qualifications",[160] has been used interchangeably with the term task sharing.[163] In the Commission we make a distinction between the two terms to emphasise the shared responsibility unique to task sharing, in which tasks are transferred from one professional to another to maximise human resources, but both the specialist provider and the provider with less training share the responsibility for a high-quality outcome of the task. In this scenario, the non-specialist provider, an associate clinician or GP, would ideally have the consultation of the specialist surgeon or anaesthetist during complicated or unusual cases.

So far, most published work documents only task shifting. Across countries of all income levels, we found 30 countries that use surgical task shifting and 108 countries that use anaesthetic task shifting,[164] but the scope of practice among associate clinicians and GPs varies widely (appendix p 113).[164]

Task shifting and sharing are a divisive subject among the surgical and anaesthetic community. In particular, concerns about safety, efficacy, and the breakdown of professional roles have resulted in a practice that is often neither regulated nor widely accepted.[29,135,156,161,165,166] Opponents of task shifting in surgery believe that the complex decision making associated with advanced surgical and anaesthetic procedures should not be shared with individuals who have had less training than fully trained specialist providers.[162,167] Concern of so-called task creep also arises, whereby an associate clinician or GP takes on more responsibility than his or her defined scope of practice because no one else is available to undertake the task. Data for clinical outcomes in specialist providers versus GPs or associate clinicians performing the same operative and anaesthetic procedures are scarce.[162] Only one formal meta-analysis[168] of studies on obstetric task shifting has been done. The study showed no difference in mortality; however, the researchers were cautious about the results owing to study design. Most published work has reported that task shifting does not increase mortality or morbidity when a small set of obstetric, general, and paediatric procedures are performed.[161,168–170]

*Reasons for the surgical workforce deficit*

Deficits in the surgical workforce are often representative of broad challenges in the public sector, particularly in health and education, including infrastructure deficits and financial constraints. Without national policies and strong coordination between central government, local governments, and the education and health sectors (both public and private), substantial mismatches in workforce supply and demand occur.[141] The surgical workforce is a dynamic system affected by a balance of entries and exits. In LMICs facing great resource constraints, incentives or push–pull factors to leave the specialty, the public sector, and the country are abundant. Factors that contribute to the entry and exit of the surgical workforce include an absence of student exposure to surgery and anaesthesia due to an absence of trainers and equipment, and greater opportunities for training, career advancement, professional development, and remuneration locally in the private sector, in other specialties, and outside the country in higher-income settings.[171–173] Individuals who work in the public sectors of LMICs, despite incentives elsewhere, might be compelled to engage in dual practice or double employment in both the public and private sectors as a means to supplement an insufficient public sector income, although at the risk of fatigue, burnout, and quality of care delivered.[130,150]

The extent to which individuals exit the surgical workforce in any country is difficult to measure. However, we calculated that an average of 12·0% (range 0·6–28·9) of all specialist surgeons, anaesthetists, and obstetricians in high-income countries are foreign nationals that have graduated from medical schools in LMICs.[174] Of those, 67·9% originate from countries below the lowest surgical workforce density of 20 per 100 000 population. Although these results are similar to those reported in other health specialties,[175] the proportion of the workforce that emigrate is higher, and the effect on source countries is felt more in specialties such as surgery and anaesthesia, than in other health specialties. In countries facing substantial workforce shortages, each additional loss perpetuates the cycle because migration leads to heavier

workloads, which makes quality care more difficult to provide and increases the chance that others will leave. This situation can decrease workforce morale and dissuade interested students from entering the specialty. Even students who are still interested are affected by the scarcity of available trainers who have the time, equipment, and ability to mentor them, which further reduces the likelihood that they will stay in the specialty or in the country.[176]

*Specialist surgical workforce training*

Entry into the surgical workforce begins with medical education and then postgraduate training. No comprehensive report on global surgical workforce training exists. An improved understanding of global practices in the training of the surgical workforce is needed to understand how training environments shape the surgical workforce, and what factors and processes help good educational outcomes (appendix p 115).

In the research done for this Commission, we found that certain similarities do exist (appendix p 115). Most medical schools and training programmes are centred in densely populated urban areas.[135] Few are located in rural communities where disease pathology and patient needs might vary and unmet need for care is usually much higher than in urban areas. Rarely is a rural surgery or anaesthesia rotation incorporated into undergraduate or postgraduate training,[135,177,178] which is problematic for several reasons. Rural exposure during training increases the likelihood of rural practice in many health professions, thereby helping to address urban and rural workforce maldistribution. Without exposure to rural medicine and surgery, trainees might graduate from training unaware of the scale of rural needs and with substantial deficits in their knowledge and competencies.[177]

**Person-years**
Defined as the number of people trained multiplied by the time it takes them to train

One way to ensure a standard of training programmes is via accreditation of both medical schools and postgraduate training programmes. When medical schools are not accredited, the quality of trainees that enter postgraduate training programmes is, arguably, compromised.[127] Likewise, unaccredited postgraduate training might compromise the quality of graduating specialists. Data collection on the accreditation of medical schools in LMICs is improving; however, it is not complete.[127,179,180] Even less data are available on the accreditation of postgraduate training programmes, and data are scarce for global practices of licensing, continuing professional development (CPD), continuing medical education (CME), and maintenance of certification (MOC),[180] all of which help to ensure quality surgical and anaesthesia care provision.

Although an increase in medical education and postgraduate training positions is a crucial step to expansion of the surgical workforce in LMICs, country-specific health and surgical workforce planning is also needed, as stated previously by many important stakeholders in the specialty.[180] To scale up the number of vacancies for medical students or postgraduate trainees without proper capacity to train or employ them after graduation is irresponsible and costly. Careful planning along the entire medical education, training, and workforce pipeline is needed to ensure that the density, distribution, and undertaking of the surgical workforce is aligned with population needs.

## The way forward

*Scale-up of the surgical workforce*

A striking scale-up in the availability and accessibility of surgical and anaesthetic providers in LMICs is needed. However, for all countries, regardless of scale up needs, attention should be paid to improvement of recruitment and retention, strengthening of training and professional development, and implementation of regulatory mechanisms to enhance quality, safety, and responsiveness to align with local priorities and needs (appendix p 118).

For many LMICs, scaling up their surgical workforce to 40 surgical, anaesthetic, and obstetric (SAO) providers per 100 000 population in just 15 years is impractical. It also might not be necessary in some contexts. For this reason, we recommend that all countries scale up their surgical workforce to 20 SAO providers per 100 000 population by 2030 as an interim goal. During the scale-up phase between now and 2030, countries should regularly reassess their surgical systems and make workforce planning adjustments based on country-specific needs. We modelled the cost and time (in **person-years**) needed to satisfy global surgical workforce needs in 2030 under two scenarios: one in which only specialist surgical, anaesthetic, and obstetric physicians make up the surgical workforce (the SAO-only model) and one in which a hybrid of SAO physicians work in collaboration with surgical and anaesthetic associate clinicians (task-sharing SAO model).

For all countries to reach a density of 20 SAO providers per 100 000 population by 2030, an additional 1·27 million providers will need to be trained (figure 10). To do this in an SAO-only model in lower-middle-income countries will cost more than $45 billion, total. This model assumes that all countries have the financial, physical, and human resources needed to scale up their surgical workforces as of today. For many low-income and lower-middle-income countries, this assumption is neither physically nor financially possible. In the hybrid task-sharing SAO model, the use of task sharing will decrease overall training costs and training time by 40% (figure 11). This decrease is further shown in figures and country-level examples in the appendix (p 120).[154]

These numbers are forward projections only and might change with population growth, surgical need, and advances in technology. An increase in the surgical workforce alone will not address the quality of care that is provided; however, quality care cannot be delivered without a trained provider. Improvements in quality can

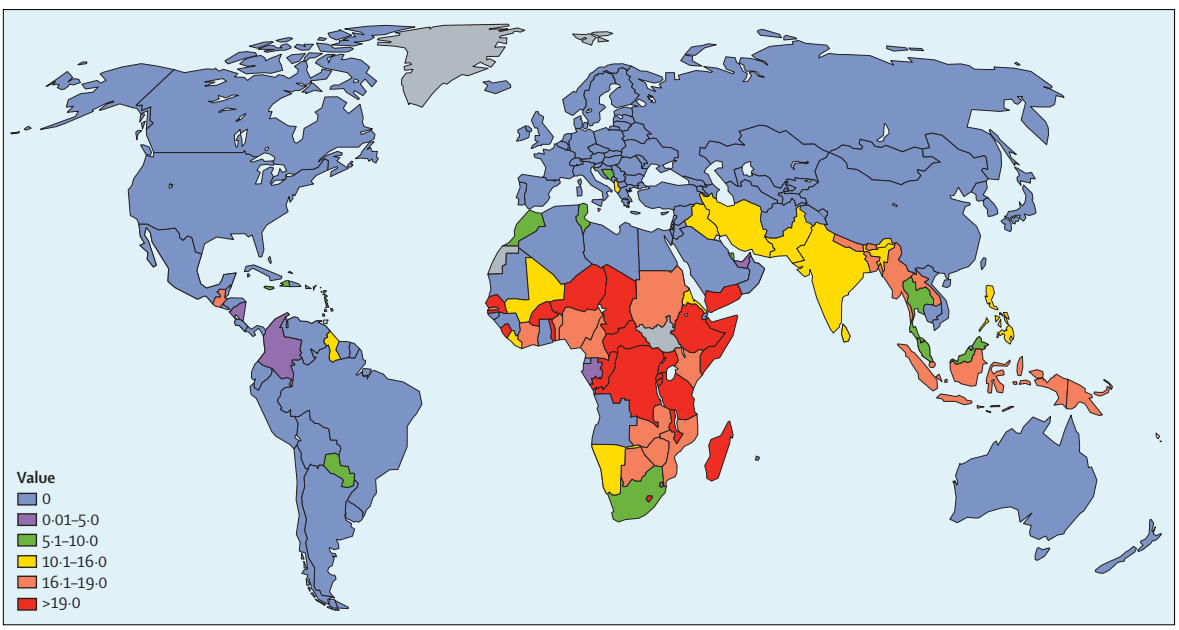



***Figure 10:*** **Change in surgical workforce density needed for specialist SAO-only model to meet 20 SAO providers per 100 000 population by 2030[154]**
Assumes retirement is at a rate of 1% per year. SAO=surgical, anaesthetic, and obstetric.

be coupled to increases in the number of trainees. Training programmes should aim to train committed and conscientious providers who are equipped with the skills needed to act as local change representatives.

*Task sharing and shifting to expand the surgical workforce*

To establish whether the use of task sharing would benefit an individual country, each country will need to assess their resources, surgical workforce needs, and models of training and service delivery. Countries should also define the scope of practice of providers engaged in task sharing, and incorporate these cadres into their national surgical plans.

We endorse task sharing as a means to expand the surgical workforce. We understand that in many instances task shifting is an accepted form of surgical and anaesthesia care delivery in which there otherwise would be none. However, task sharing is a mechanism to maximise human resources and encourage their efficient and safe deployment via the collaborative use of specialist providers and GPs and associate clinicians. Although GPs and associate clinicians might function independently in this scenario, we believe a specialist provider should always be available to give assistance, either locally or remotely.

We maintain that associate clinicians and GPs are not meant to replace specialist surgeons, anaesthetists, or obstetricians. Rather, they should complement the existing system. Professional protectionism by specialist providers towards associate clinicians and GPs can be prevented by use of clear scopes of practice and assurance that all stakeholders, including regulatory bodies, accept the cadre of associate clinician and GP surgical and anaesthetic providers.

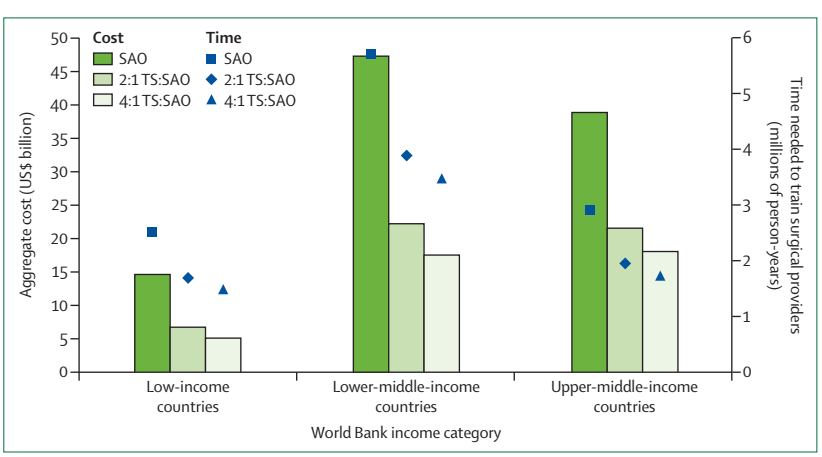



***Figure 11:*** **Cost and time of SAO-only model versus task-sharing SAO model needed to scale up the surgical workforce[154]**
Assumes retirement is at a rate of 1% per year. The cost and time needed to scale up the surgical workforce in low-income, lower-middle-income, and upper-middle-income countries in an SAO-only model versus a hybrid task sharing SAO model. The use of task sharing can decrease costs and time needed to scale up the surgical workforce to 20 providers per 100 000 population by 40%. SAO=surgical, anaesthetic, and obstetric. TS=task sharing.

Both associate clinicians and GPs who do surgical or anaesthetic procedures should be trained to high and clearly defined standards with competency-based curricula from accredited institutions. However, training of associate clinicians and GPs should not divert resources away from the training of specialist providers. Licensing, relicensing or maintenance of certification, and CPD should also be required for all

associate clinicians and GPs. Training programmes should be initiated locally with ongoing local supervision after the completion of formal training to ensure maintenance of skills and competencies. To prevent associate clinicians and GPs from feeling pressured to work outside their scope of practice, adequate referral mechanisms and transportation systems for advanced-level cases are needed. Associate clinicians and GPs need satisfactory supervision, career opportunities, and remuneration, to avoid attrition from the specialty, similar to that of their specialist counterparts.[162,181,182] A clear career progression path for associate clinicians and GPs should exist to maintain interest and to increase retention (appendix p 123).

*Resources for expansion and training of the surgical workforce*

The scale-up of the surgical workforce does not necessarily need the creation of new training centres. Simple innovations can be used to increase the breadth and volume of surgical and anaesthetic training, including the use of retirees, the private sector, and the NGO sector as educators. Both the private and NGO sectors are often adequately resourced and with a high case volume, making them rich environments for learning, as seen in the educational programming of the NGO, Smile Train (appendix p 124).[178] We feel strongly that, outside of acute crisis situations, NGOs should have a training component hardwired into their programmes to ensure the durability of their effect. In an ideal situation, governments would work in partnership with NGOs and private sector providers to ensure sufficient education, training, CPD, and MOC of their surgical workforce.

Partnerships with other countries, both regionally between countries of similar economic status and internationally between countries of high-income and low-income or middle-income status, are common in global surgery and can be beneficial for all parties under the right conditions.[183,184] Bidirectional learning about disease patterns, treatment algorithms, research, and standards of care can take place. Examples of collaborations between LMICs include postgraduate training programmes in South Africa and Uganda for medical school graduates without training opportunities in their home countries[185] and the Medical Education Partnership Initiative, which connects 12 sub-Saharan African countries via an overarching theme to strengthen the sub-Saharan African health workforce.[184] Regional partnerships allow countries from similar contexts to share resources and experiences. Regulatory agreements can be made between countries to prevent poaching of visiting trainees from their source countries. High-income countries can also have an important role in regional partnerships, through the provision of financial, technical, or specialist support.

For example, in 2007, a partnership was established between the Uganda Society of Anaesthesia and the Association of Anaesthetists of Great Britain and Ireland (AAGBI) to support postgraduate anaesthesia training in Uganda. In Uganda, doctors wishing to train for the 3-year Masters of Medicine degree in anaesthesia are required to pay tuition fees and do not routinely receive a salary during training. This situation acts as a barrier to recruitment compared with other postgraduate programmes for which external scholarships are often available.[171] The AAGBI and UK partners pay an allowance directly to the trainees (up to £3000 per year), and for the first 3 years of the scheme, the University of California, San Francisco Global Partners in Anaesthesia and Surgery also contributed tuition fees. An in-country AAGBI volunteer supports the local trainers who actively encourage medical students to join the specialty. Overseas partners support the new trainees in their research projects and in short-term funded observerships or clinical attachments in Canada, the UK, and the USA. So far, the AAGBI has supported 51 doctors to do postgraduate training in anaesthesia: 48 are training or working in Uganda, one is in Kenya, and one is in the USA. Only one did not complete training.

The World Federation of Societies of Anaesthesiologists (WFSA) has also contributed to funding educational initiatives for anaesthesia providers.[186,187] For example, the WFSA works collaboratively with national societies and other organisations to provide training fellowships in Chile, Colombia, Argentina, Brazil, Thailand, Malaysia, India, South Africa, Kenya, Israel, and soon Serbia and Ghana. The main aims of these fellowships are to support and develop potential clinical leaders, establish clinical networks, and strengthen institutions. The WFSA is also committed to strengthening anaesthesia capacity by focusing their fellowship training efforts on individuals younger than 40 years who have been fully trained in their home country and have plans to return to their home country, preferably with a position in a teaching hospital.[187]

Direct high-income country and LMIC partnerships can also be beneficial. In the 1000+ OBGYNs project publication,[127] representatives from sub-Saharan African countries delineate areas of need that might be met with high-income country partnerships: building accreditation bodies, improvement of research capacity, introduction of new technologies, provision of library resources, and expansion of human resources by having high-income country partners stay in their country to both treat and teach.[127] Results of a descriptive, cross-sectional survey[188] of surgical and anaesthetic trainees in Uganda similarly showed that collaborations with high-income-country partners are most helpful in educational and training capacities.

Both regional and international partnerships have previously been restricted by physical distance; however, internet expansion has the potential to change this. Great advances have been made with open-source, online

classes, and teleconferencing education (appendix p 126).[189] The internet also allows for within-country training and research and improved connectivity between urban hospitals and those in more geographically isolated locations. To capitalise on this, improved access to high-speed, affordable internet is needed, especially at the first-level hospital level. Internet access has additional benefits because it can decrease the professional (and social) isolation of the rural surgeon with online courses or tele-education for training and CPD.[190]

*Train responsibly*

Strong leaders and change agents are needed within the surgical workforce at a local, national, and international level to advance surgical and anaesthesia care and to improve education and training. Providers in LMICs should be empowered with the resources of a transformative education that combines acquired knowledge with professionalism to develop both sound clinicians and effective leaders.[180] For a transformative education to be possible, several basic components are needed including adequate infrastructure and supplies with which to teach, sufficient balance of trainers and trainees, appropriate prioritisation of training locations and content for both rural and urban communities, and regulation of training via accreditation, licensing, and relicensing bodies. All of these are feasible with proper governmental prioritisation and collaboration with health educators.

To train responsibly, training programmes should be embedded within the cultural context of the community. To meet local needs and address workforce maldistribution, training should contain strong generalist and rural components. In recognition of this, the College of Surgeons of East, Central, and Southern Africa (COSECSA) has centred their postgraduate training opportunities within first-level hospitals. Similarly, in most COSECSA member countries, government-funded subsidies for training are only granted to individuals who have served in a rural post before their postgraduate training.[191] To achieve adequate population coverage with surgical and anaesthesia care, providers will need to be confident and skilled in the delivery of surgical care in both rural and urban centres. Ideally, training would be offered within the country of the student's origin to increase in-country retention.[192] When trainees are trained in their home countries they become adept at using the resources that will be available to them throughout their career.[135,165,192] For countries without available specialty or subspecialty training, trainees might initially need to find training outside of their home country. However the eventual goal should be self-sufficiency with high-quality, in-country training, and licensing for all surgical and anaesthetic specialities and subspecialties.

As part of responsible training, the health needs and local resources of the community should inform the competencies needed of practitioners and establish educational curricula. Such competency-based training (CBT) focuses more on the acquisition of context-appropriate skills and knowledge than on the passage of time.[180] This method allows competent health professionals to contribute to the specialty when they have proven their ability to do so safely, and for some, might decrease time spent in training. Many professional surgical bodies are transitioning to CBT curricula including those in Canada, the USA, and India.[193–195] CBT can be applied to any health specialty, and the International Federation of Gynaecology and Obstetrics' global competency-based fistula surgery training manual provides a good example.[196]

Using low-cost simulation is one way to develop and assure competency that is not at the expense of patients or scarce hospital supplies. Simulation is often used in surgical and anaesthetic education to teach crucial steps of a high-risk procedure in a low-risk environment. Skill practice in simulation might further accelerate acquisition of competencies, thereby shortening time in training.[197] Such activities might increase exposure to the specialty for students and trainees who would otherwise be shut out from the operating theatre owing to a shortage of supplies.

Train the trainer (TTT) is a way to teach core competencies and to ensure their promulgation in the future. In TTT programmes, students are taught to deliver essential care and to train others to do the same. Rwanda's Human Resources for Health Program provides a good example (panel 4). Other examples include AAGBI SAFE course for anaesthetic clinical officers[186] and CURE Hydrocephalus neurosurgical training in sub-Saharan Africa (described in one of the Commission's teaching cases). Thousands of health providers and patients have been reached as a result of a TTT programme.[198]

For more on the **Commission's teaching cases** see http://www.globalsurgery.info/teaching-cases/

To sustain the investments made in the surgical workforce through education and training, retention should be addressed at several levels: retention within the surgical field, retention of health professionals within their home country, retention in the public sector, and retention in geographic areas of need, particularly rural areas. Low-income countries should be able to match the opportunities for training and career development of their richer neighbours or else the established pattern of so-called brain drain will persist. Issues of retention of surgical and anaesthetic providers in rural areas in countries of all economic levels should also be addressed.

A Cochrane review[199] published in 2014 reported that no documented studies adequately show that provision of increased salaries and financial incentives, bonding (in which trainees commit to working in an underserved area after training is subsidised), or scholarships for medical education and training would be effective in prevention of the migration of health workers from one sector to another. However, very

### *Panel 4*: Rwanda's Human Resources for Health Program

The Rwanda Human Resources for Health (HRH) Program was launched in August, 2012. This ambitious effort of the Ministry of Health of Rwanda is the largest known bilateral effort to strengthen health-care training and to expand the health workforce in a resource-limited setting. This 7-year programme increases the quantity and quality of training for physicians, nurses, hospital managers, and dentists. HRH brings together a consortium of 14 US academic medical centres and universities to work in partnership with the Ministry of Health and the University of Rwanda. Roughly 100 faculty from US institutes are recruited to Rwanda in each of the first 3 years of the programme, with decreasing numbers in the subsequent years. These employments are mainly year-long contracts. The US faculty are integrated into the departments of their respective schools at the University of Rwanda, and are posted at the teaching sites around the country. The faculty are tasked with mentoring Rwandan postgraduate students in their specialty, increasing their exposure to subspecialty modules relevant to their specialty, and providing didactic and clinical teaching. US mentors are further paired with Rwandan clinical faculty to strengthen their capacity as instructors and educators.

The surgical component of the HRH Program (including the surgery, otolaryngology, and anaesthesia departments) is supported by three US institutions. The programme covers faculty salaries. In the first 2 years of the programme ten full-time equivalents of surgeons, two otolaryngologists, and two anaesthesiologists were recruited each year—with decreasing numbers over the remaining years as the Rwandan faculty increases.

The Rwanda HRH Program is funded by the US Government, with funds transferred directly to the Ministry of Health of Rwanda. The Ministry of Health is then responsible for allocation of funds and administration of the programme. The novelty of the HRH Program model lies in the direct contracting between governments, without the use of third-party agencies. During the 7-year period, the HRH Program will be funded at roughly US$170 million.

As a result of these efforts, the Department of Surgery has delineated four differentiated residencies (general surgery, urology, orthopaedics, and neurosurgery), has increased the mean annual intake of new postgraduates from four to 13, and has now begun distributing trained surgeons to decentralised hospitals outside of the main urban areas. With 5 years left in the programme, it will be crucial that these gains are consolidated and that sustained capacitation and broad-based skill transfer is ensured.

little quality research into this topic has been done.[135,199] Smaller studies have noted that for all members of the surgical workforce, increased training opportunities, including improved supervision, CPD, and retraining opportunities might increase workforce morale and retention in both the specialties of surgery and anaesthesia and in rural areas.[162,200–203] Such opportunities also ameliorate the professional isolation of the rural provider, further contributing to retention in rural areas (appendix p 127).[204]

Exposure of students to a local, rural practice and its rewards can also increase rural recruitment and retention.[205,206] In a mixed methods study to assess the effect of a community-based education and service (COBES) curriculum in Uganda, researchers reported that 83% of alumni of the COBES course attributed their willingness to work in a rural area, at least in part, to COBES.[206] However, to be successful, rural rotations in any training programme should be adequately supervised and supported to ensure quality educational experiences that encourage future return to rural areas.

Further, loan repayment programmes and bonding might not be proven to retain health workers in underserved areas in the long term, but they are a way to ensure that a provider is in a rural area for a specified duration.[207,208] This is a system used by the National Health Service Corps in the USA[209] and the Pan-African Academy of Christian Surgeons[210] to ensure an increased accessibility to high-quality rural surgical care.

#### *Workforce regulation*

We endorse accreditation of all surgical workforce training programmes. However, debate exists about whether accreditation would best be governed at a national or regional (between countries) level. Advocates for accreditation of training programmes at a national level argue that it will promote training according to the needs of the population. However, proponents of regional accreditation argue that national accrediting bodies might lower standards to help increase the number of accredited schools and hospitals. The Commission therefore recommends that countries should first establish national accreditation systems or adopt those of regional regulatory bodies if they are unable to establish their own. As institutions progress, international accreditation bodies can recommend benchmarking standards for which national organisations can achieve. The accreditation system, irrespective of its level, should be transparent, non-profit making, accountable, and efficient.[211] This proposal holds true for all accrediting institutions of every component of the surgical workforce.

We recommend that all surgical and anaesthetic providers obtain licensure on the basis of competency before entering practice. Additionally, life-long learning in the form of CPD and CME should be encouraged and regulated by a governing body that ensures the quality provision of care.

In countries where licensing, CPD, CME, and MOC are not endorsed, we strongly recommend that countries consider retraining or relicensing their providers. CPD, CME, and MOC are important means to refresh and update knowledge and ensure standards of practice are maintained. In the USA, surgeons who practise in a solo practice are more likely to pass relicensing examinations if they participate regularly in CME activities.[212,213] Furthermore, in a multinational survey of anaesthetic providers,[214] more than 90% of respondents felt that CPD improved their delivery of patient care. For clinical officers working in rural Tanzania, provision of avenues for CPD is one of the most powerful incentives to stay in their jobs and rural posts.[203] However, people who work and serve in remote areas with underserved populations are unlikely to have access to internet, CPD

or CME courses, or other professional discourse to stay up to date with evolving standards of care.[190,215] Licensing and CPD, CME, and MOC should be required for all graduates of training programmes. CME and CPD should be provided by internet or telephone, or enabled with an educational stipend, to decrease professional isolation and increase the confidence and competence of the rural provider.

### Recommendations for workforce, training, and education

*National*

- Ministries of health should record the density and distribution of all surgical, anaesthetic, and obstetric providers including specialist providers, GPs, and associate clinicians.
- Ministries of health should develop surgical workforce plans to achieve surgical workforce densities of 20–40 per 100 000 population with adequate rural and urban distribution by 2030 as an interim goal; this goal can be reset then based on local evidence and community needs.
- All surgical workforce training programmes should have a required rural training component that is sufficiently mentored and supervised.
- All graduate and postgraduate training programmes should be accredited.
- All actively practising providers should be licensed or relicensed through available and affordable competency-based examinations, CPD and MOC.
- Access to reliable internet, information, and mentoring is needed at all training sites and first-level hospitals.

*International*

- Ministries of health, finance, and education and regional professional bodies should collaborate to support regional training and education opportunities.

*International funding agents*

- In low-income countries, multiyear funding should be directed toward large-scale health system strengthening programmes that include education of the entire surgical workforce.
- In middle-income countries, funding should be directed toward rural service incentives to improve surgical workforce distribution.

*WHO*

- Partner with ministries of health to record and publish surgical workforce density and distribution in all UN-member countries annually.

*NGOs, professional organisations, high-income country academic institutions*

- Work in partnership with local institutions to improve surgical capacity through longitudinal educational programmes that do not drain human resources away from the public system.

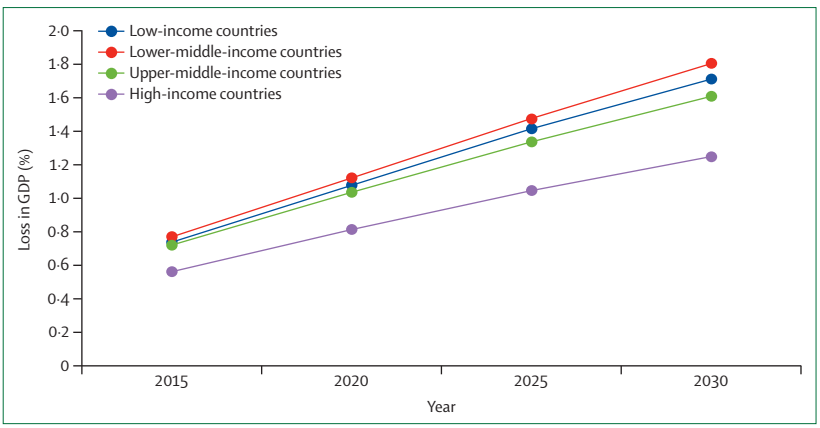



***Figure 12:*** **Annual value of lost economic output due to surgical conditions[58]**
Data are percentage loss of GDP by World Bank income class, based on the WHO Projecting the Economic Cost of Ill-Health (EPIC) model (2010 US$, purchasing power parity). GDP=gross domestic product.

## Economics and financing

For **key findings from the economics and financing working group** see appendix p 129

### The present situation

*The case for investment in surgical and anaesthesia care in LMICs*

To appreciate the full effects of untreated disease on populations and the benefits that treatment can provide, it is crucial to understand the economic impact of surgical conditions. However, although economic evidence has become a core research area in many parts of health care, evidence for the economic effects of surgical conditions in LMICs is scarce.[216–219]

Earlier in the report we presented the Commission's work that estimated the economic impact of surgical conditions in LMICs between 2015 and 2030 using a value of lost output approach, which describes the economic impact of disease in terms of losses in GDP as a result of depletion of the labour supply and capital stock.[220] We showed that without urgent and accelerated investment in surgical scale-up, LMICs will have projected losses in economic productivity estimated cumulatively at $12·3 trillion (2010 US$, purchasing power parity [PPP], lower bound estimate $6·9 trillion, upper bound estimate $20·6 trillion) between 2015 and 2030. The annual value of lost economic output secondary to surgical conditions will have a profound effect on GDP (figure 12). Lower-middle-income countries will have the greatest losses: by 2030, our estimates suggest that surgical conditions in lower-middle-income countries could reduce annual GDP growth by almost 2%.

However, GDP alone cannot capture the full value of better health. We therefore assessed the impact of surgical conditions worldwide and at the country level using a broader economic measure: the value of a statistical life (VSL).[57] VSL estimates are derived from economic studies that assess the monetary value individuals place on small changes in mortality risk, and therefore captures non-market welfare losses, including the value of good health itself, that go beyond market valuations such as national income.[221,222]

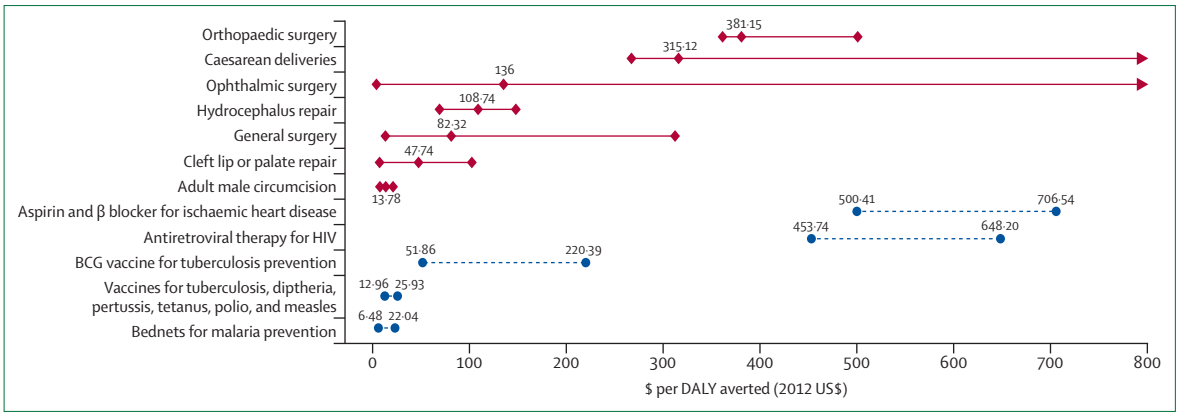



***Figure 13:*** **Cost-effectiveness of surgery in low-income and middle-income countries compared with other public health interventions**
Data points are medians, error bars show range. Surgical interventions are denoted by the diamonds and solid lines, public health interventions by the circles and dashed lines. Reproduced from Chao and colleagues,[53] by permission of Elsevier. DALY=disability-adjusted life-year.

Using the VSL approach, we show that at least $14·5 trillion (2010 US$, PPP; lower bound estimate $9·9 trillion, upper bound estimate $22·4 trillion) in total economic welfare was lost annually secondary to mortality and morbidity from surgical conditions in 2010. In LMICs, $4·0 trillion in total economic welfare losses occur predominantly in the LMIC super-region of southeast Asia, east Asia, and Oceania. Most of the economic welfare losses were in high-income countries, which is in part a result of the VSL methods. Intuitively, an individual's willingness to pay to reduce their risk of mortality positively correlates with income, and therefore it is not surprising that VSL varies across countries of different income. VSL methods, including their strengths and weaknesses, are explored in an accompanying study.[57]

Surgical and anaesthesia care in LMICs has been perceived as too expensive and too complex to be a public health priority in resource-poor settings. However, many examples exist in which safe, quality surgical and anaesthesia care is provided to such communities, at low cost, in both the public and the private sectors—notably in India and Pakistan.[223–225] Cost-effectiveness analysis, using the WHO cost-effectiveness ratio,[226] suggests that surgical and anaesthesia care in LMICs is a good health investment, even when accounting for capital investments.[53] The cost-effectiveness ratios of many surgical interventions compare favourably with those of other widely used public health strategies in low-resource settings (figure 13).

Typically, surgical and anaesthesia care are not delivered as single isolated interventions, rather a series of interventions delivered within a platform of clinical care. Similarly, policy makers are usually faced with decisions about funding platforms, rather than individual procedures. Most cost-effectiveness analyses of surgical interventions in LMICs have focused on just one surgical procedure, and therefore do not capture the full value of provision of a surgical service. Nevertheless, a small number have assessed the cost-effectiveness of an overall surgical service. Debas and colleagues[5] showed that a platform of surgical and anaesthesia care delivered within a first-level hospital could provide surgical services that were cost effective under a series of different assumptions in six LMIC super-regions. First-level hospitals were substantially more cost effective than were community health centres as platforms for delivering surgical and anaesthesia care in all LMIC super-regions, and cost as low as $33 per surgical DALY averted in sub-Saharan Africa.

Although surgical and anaesthesia care can be highly cost effective as a health intervention, they can still be catastrophically expensive for individuals if they are not financially protected by publicly financed insurance. Household catastrophic expenditure and impoverishment as a result of accessing health care in LMICs has emerged as a major global health challenge.[41,44,56] Before the work of this Commission, little was known about the amount of catastrophic expenditure attributable to surgical and anaesthesia care in LMICs outside of emergency obstetric care.[227–230]

This Commission has estimated that about 33 million individuals face catastrophic expenditure from accessing surgical and anaesthesia care each year on the basis of OOP costs of surgery alone. A further 48 million people have catastrophic expenditure as a result of the direct non-medical costs of seeking care, including transport and food costs.[28] On the basis of earlier estimates of total catastrophic health expenditure worldwide,[44] catastrophic expenditure related to the direct medical costs of surgical and anaesthesia care would account for about 20% of all cases of catastrophic health expenditure worldwide. Importantly, many other people do not seek surgical and anaesthesia care at all, or decide not to pursue surgical treatment as advised, because they cannot afford the costs of such care.[231–233]

A new prospective, multicentre cohort study assessing the socioeconomic outcomes of surgery for cancer in eight countries in southeast Asia, reports the impact on patients of the OOP costs of surgical care. Of the

4584 patients designated for surgery as part of their cancer care at baseline, 25% incurred financial catastrophe, defined in their study as costs of hospital admission exceeding 30% of annual household income, and 18% had discontinued treatment (no hospital admission) at 3 months after diagnosis. Women were reported to have greater risk of financial catastrophe than were men; low socioeconomic status was generally associated with an increased risk of death, treatment discontinuation (including failure to undergo the initial planned operative procedure), and financial catastrophe.[47]

Household financial shocks from accessing surgical treatment might be particularly large because the need for surgical and anaesthesia care is often time critical, unpredictable, and resource intensive, making it difficult to pre-plan or save for. A study in rural Bangladesh assessing disease-specific impoverishment from annual OOP payments for health care showed the poverty effect on households of time-critical surgical conditions. Of the households undergoing acute cholecystectomy, appendectomy, and emergency hysterectomy, 22·2%, 12·5%, and 9·8%, respectively, were pushed into poverty. This compared with an overall annual impoverishment average of 3·4% for all health care.[48]

*Sources of health financing*

Health financing plays a key role in the development of equitable, efficient health systems and optimal health outcomes.[234] National health financing has three major sources: the public sector (general revenues [ie, raised from taxation] and social insurance contributions [ie, contributions from the insured, the insured's employer, or the state into a public insurance scheme]), the private sector (OOP payments and private insurance), and external sources (eg, grants from international funding agencies or concessional loans from development banks). Most LMICs use a combination of all three sources, but poor coordination and alignment of activities between different financing sources might have contributed to the development of fragmented health systems and surgical services.

An understanding of domestic and international financial flows to surgical and anaesthesia care is crucial to quantify the financing gap in LMICs. Yet, just how much of domestic and international health financial flows are directed towards surgical and anaesthesia care in LMICs is unknown. Most of the global development assistance for health (DAH) databases (eg, the Organisation for Economic Co-operation and Development [OECD] Development Assistance Committee [DAC] database and the OECD Creditor Reporting System [CRS] database) do not specifically collect data for surgical services, and national health accounts rarely track domestic spending on surgery. Tracking of surgical financing flows is important because it helps to identify funding gaps, ensure that resources materialise from promises, and encourages accountability and transparency.

We reviewed 958 country-generated national health accounts from 1996 to 2010 in an attempt to track domestic spending on surgical and anaesthesia care. Only Georgia and Kyrgyzstan, both lower-middle-income countries, routinely reported expenditure on surgery within their national health accounts.[235] The difficulties with the tracking of domestic spending for surgical and anaesthesia care is in part a result of the accounting framework for national health accounts, which does not disaggregate health expenditure by intervention or clinical service.

By searching annual tax information for non-profit organisations, US Agency for International Development (USAID) annual reports, and the National Institutes of Health (NIH) Research Portfolio Online Reporting Tools (RePORT) database, we sought to estimate contributions to surgical and anaesthesia care in LMICs from the USA, a major international donor in global health. Although limited by incomplete datasets, several patterns emerged. Most of the US-based non-governmental support directed towards surgical and anaesthesia care in LMICs has focused on elective ophthalmology and cleft lip and palate repair and typically on support of short-term surgical delivery by international teams, rather than on long-term capacity building. Governmental support from USAID has focused on obstetric fistula care and research funding from the NIH has focused on trauma research. By comparison with other global health areas, surgical and anaesthesia care has received a very small proportion of funding from US non-governmental and governmental sources[236] (appendix p 130).

For the **NIH RePORT database** see http://report.nih.gov/

*Payment mechanisms*

Payments for health services can be direct or indirect. Direct payments, or user fees (fee-for-service payments without the benefit of insurance), are paid OOP, usually at the point of care. Indirect financing or insurance mechanisms are based on pooling risk. Here, target groups pay a regular contribution, either through general taxation or insurance models (involving premiums and copayments), from which the expenses of treatment are financed when a member of the pool becomes unwell.[237] Generally, as countries develop, their health financing profiles change, moving from a heavy reliance on direct OOP payments towards indirect financing mechanisms that pool risk (general tax revenue, social insurance, or private insurance models).[234]

Little has been reported about how surgical and anaesthesia care is financed within health systems in LMICs. Interviews with key informants during the process of the Commission suggest that in several low-income countries in Africa and south Asia user fees make up the bulk of financing mechanisms for surgical and anaesthesia care provided within the public sector and within private for-profit facilities, even when the stated means of health financing in a country is general taxation.[96] Informants reported that user fees acted as a

substantial barrier for patients accessing surgical and anaesthesia care in their countries. User fees contribute to the high levels of catastrophic expenditure attributable to the use of surgical and anaesthesia care in people from low-income countries. Two previous studies[231,237] support the notion that financial barriers substantially affect use of surgical services in LMICs.

User fees at the point of care tend to be regressive, placing a proportionately increased burden on people with a low income.[238] Conversely, use of health services increases when they are made free at the point of care. For example, removal of user fees for caesarean delivery in Sudan and Senegal was associated with a significant increase in the use of emergency obstetric facilities.[239,240] Similarly, uptake of paediatric surgical services increased by five-fold in Sierra Leone after the introduction of a free health-care policy for children younger than 5 years.[241] The removal of user fees for cataract surgery in rural China doubled uptake of services[242] and contributed to poverty alleviation, especially in the poorest of the study population.[216]

In addition to official user fees for surgical services, two other types of OOP expenses are often encountered by households when accessing surgical and anaesthesia care in many LMICs. These costs are other medical charges such as the costs of surgical supplies (including the surgical provider's gloves, sutures, dressings, intravenous fluids, and antibiotics), which are often met by patients themselves owing to a shortage of supplies in public facilities, and non-medical costs such as the cost of transport and food. These expenses contribute substantially to the overall payments made by households. Non-medical costs can act as a financial barrier to care and a source of medical impoverishment, even when surgical and anaesthesia care itself are free.[243] Very few insurance schemes or general taxation financing mechanisms for health make provision for non-medical costs.[244]

In contrast with user fees, indirect financing with either general taxation or insurance contributions spreads out payments for health services, which minimises costs to users when they become unwell.[238] When general taxation is used, the tax structure of the country contributes substantially to how equitable payment contributions are. In LMICs, taxation is not always progressive; several countries still fund health and other public services using proportional or regressive tax structures[245] that disproportionately affect people with a low income. Government spending on health also varies widely, as do the areas within the health budget that receive priority. Generally, however, government health expenditure per person correlates with operative volumes (appendix p 132). General tax revenue funds coverage of a basic package of maternal and child health services in several LMICs (eg, Afghanistan and Sierra Leone),[246] but this package does not usually extend to all health services. Surgical services are often one of the last services to be covered despite the high financial risks associated with use of surgical and anaesthesia care.[46] Even when public spending does cover surgical and anaesthesia care, the allocation of funding might not benefit those most in need if coverage of services is poor or if other barriers impede service uptake.

Most LMICs have found that government funding is necessary for achievement of good health coverage. A contribution-based risk-pooling mechanism, such as national social insurance, often does not work in LMICs because most of the population usually subsist on low incomes, a large informal sector exists, and populations are often geographically dispersed, all of which makes collection of premiums very difficult. Because of these restrictions, contribution-based risk-pooling mechanisms have usually struggled to provide good coverage for people with a low income, even for the most basic health services. Rwanda, a notable exception, has successfully implemented a national community-based health insurance model with more than 90% population coverage.[247]

Private insurance used in isolation is not a solution for surgical coverage, generally only insuring the healthiest and most often wealthiest people, thereby leaving sick and poor people uninsured.[234] Likewise, a dual system with government insurance for poor people and informal sector workers and private insurance for formal sector workers and wealthy people can also lead to inequalities and is unsustainable.

While risk pooling is important for equity and financial risk protection, strategic purchasing drives quality and efficiency. In many LMICs, the government directly funds government-run or government-owned health facilities (including those providing surgical and anaesthesia care) by paying for their inputs, such as personnel, medicines, supplies, and equipment, through line-item budgets. Little attention is given to how financial incentives or other mechanisms can motivate surgical providers to improve quality and efficiency, or to respond to patient demand. As a result, productivity is often low, quality of service is highly variable, and physician or surgeon absenteeism in the public sector is frequent. Such input-based funding also has negative equity effects. When wealthy individuals are dissatisfied with poor-quality surgical services in the public sector, they seek care in the more expensive private sector, an option that is financially out of reach for people with a low income.[248]

In contrast, strategic purchasing includes proactive and explicit decision making on the basis of predefined outputs and outcomes. This method links payment to information provided about the delivery of these predefined products and selects the most qualified and efficient provider. In doing so, the purchaser seeks to improve efficient allocation of resources and effective service delivery to maximise population health and reduce financial risk.[251] A key policy instrument that improves the effectiveness of purchasing is provider

payment method, a mechanism through which funds are transferred from the purchaser to the provider of health services. So far, no research has been done to characterise how different purchasing strategies affect surgical providers' behaviour in treatment decisions in LMICs, and thus the quality and efficiency of service provision.

In the past few years, pay for performance (P4P) programmes (or results-based financing) have gained support above traditional provider payment methods to drive improvements in quality of care. P4P programmes link payment of individual providers or institutions to predefined outcome or output and activities that have established evidence of being cost effective in terms of health outcome improvement. However, the evidence for the effectiveness of P4P in the improvement of outcomes in LMICs is mixed. Financial incentives aimed at individual providers, or at patients, have been shown to have short-term benefits for simple and distinct, well defined behavioural goals,[250] particularly for health facility deliveries and health care for children younger than 5 years.[251] To the best of our knowledge, no studies have examined the effectiveness of P4P in the context of surgical-care provision in LMICs. P4P has some potential risks if financial incentives are tied to the wrong health indicators or outputs, or when they encourage gaming the system (providers who only do low-risk surgical procedures so that they have better outcomes and better financial compensation) at the expense of other areas of health-care provision.

## The way forward

### *Scale-up of surgical and anaesthesia care as an investment*

Financing and financial mechanisms for surgical and anaesthesia care in LMICs are inadequate, do not meet current health needs, and will not in the near future. Two key aspects should be addressed. First, substantial surgical scale-up is needed in most LMICs to meet clinical demand, improve health and welfare, and fully realise associated economic gains. The costs of scale-up will need to be met through both domestic and international financing mechanisms in many LMICs, especially low-income countries. Second, the large, catastrophic costs borne by patients for surgical and anaesthesia care should be addressed through improved deployment of equitable health financing mechanisms. Several possibilities for scaling up surgical and anaesthesia care while assuring financial risk protection exist for countries.

In the Commission we examined different scenarios for scale-up of surgical and anaesthesia care from 2012 to 2030 in LMICs. To achieve rates of surgical growth similar to a best-performing LMIC (eg, Mongolia), the total scale-up costs for 88 LMICs during this time (2012–30) would be about $420 billion. This number represents 1% of total annual health expenditures in upper-middle-income countries currently, and approximately 8% and 6% for low-income and lower-middle-income countries, respectively. In countries with little surgical infrastructure (most low-income countries and many lower-middle-income countries) the costs of scale-up are largely related to the size of capital investment needed. Additional costs for training consultant surgeons, surgical officers, and associated personnel were not included in the model presented in the Commission and will need to be met through investment in human resources for health programmes. Although the scale-up costs are large, the costs of inaction are higher, and will accumulate progressively with delay (figure 4). Scale-up of surgical and anaesthesia care should therefore be viewed as an investment, not a cost.

### *Expansion of sources of health financing*

The capital and operating investments in scaling up surgical and anaesthesia care in LMICs can be met through various sources.[56] The 2013 *Lancet* Commission on Investing in Health[56] recommended three main ways by which countries could increase their health financing: increased mobilisation of domestic resources (eg, general taxation; taxation of tobacco, alcohol, and sugar; and taxation of multinational corporations), intersectoral reallocations and efficiency gains (eg, reduction or elimination of fuel subsidies), and contributions from external resources (eg, both traditional DAH and innovative financing mechanisms, such as airline ticket solidarity taxes).

The *Lancet* Commission on Investing in Health also identified five key enabling advances of the past two decades of global health that can be further leveraged to increase health gains by mobilisation of resources and reduction of inefficiencies in the coming two decades. In table 4 we consider how these gains can be used specifically to mobilise resources to advance surgical and anaesthesia care in LMICs.

Although consensus exists that the main responsibility for financing of health services rests with governments through domestic revenue generation, in the short-to-medium term, finance of surgical scale-up in many low-income countries and in some middle-income countries is not possible through national health expenditure alone. To attempt to do so would require countries to apportion an unrealistically large amount of the health budget towards surgical and anaesthesia care. Therefore, to accelerate the scale-up of surgical services in many LMICs, external sources of financing will also be needed. Because surgical care spans many services and health delivery platforms, surgical scale-up costs often overlap with the broader costs of health systems strengthening and other priority health areas. To avoid further so-called verticalisation of global health financing around individual interventions, as occurred during the MDG era, surgical and anaesthesia care might be best supported by DAH aimed at health systems

| | Effect on global health and surgical and anaesthesia care, 2000–15 | Opportunities for surgical and anaesthesia care, 2015–30 |
|---|---|---|
| Focused domestic attention to health | Many LMICs instituted important health systems reforms, often accompanied by increased domestic health financing. However, these reforms were focused on infectious diseases and child and maternal health, and in most countries did not benefit (and in some cases harmed) surgical services. Notable exceptions are Mexico, Mongolia, Papua New Guinea, and Rwanda | Domestic recognition of the effect of non-communicable disease and injuries in LMICs is increasing. Realignment of health priorities and financing to show changing disease patterns should increase funding of health systems development, hospital care, and primary care and allow for increased domestic funding to flow to the development of surgical services needed to manage these challenges |
| Growing effect of MICs | Economic growth of some large MICs led them to become financially self-sufficient in health; some are now aid donors and international suppliers of key health technologies themselves (eg, drugs, vaccines, and surgical instruments) | Economic growth in many countries will create fiscal space for increased domestic spending on health, including surgical services. MICs can increasingly participate in and lead the transfer of cost-effective solutions to surgical and anaesthesia care that they have developed through so-called South–South collaboration and exchange |
| Increased funding and institutional innovations for health research and development | Funding for research and development into infectious diseases, neglected tropical diseases, and child and maternal health increased facilitation of development of new drugs, vaccines, and diagnostics. Product development, public–private partnerships, and institutional capacity in MICs led to a healthy product pipeline. | Surgical and anaesthesia care in LMICs would benefit from a greater share of research and development funds. The development of high-quality, low-cost surgical innovations represents a viable focus point for research and development and product development by public–private partnerships, especially given the potential for reverse innovation to high-income countries, which are also increasingly focused on cost constraint |
| Mobilisation of development assistance for health | Global health architecture was transformed by new actors (private foundations and global funds and alliances). An explosive rise in development assistance for health occurred. However, this rise was mainly channelled into the health-related MDGs, and surgical and anaesthesia care did not benefit from these new resources | The core functions of global health and the development of robust, responsive, and efficient health systems have been underfunded, which should be reversed. Surgical and anaesthesia care will benefit from increased development assistance for health systems, as well as greater aid efficiency. Mobilisation of development assistance for health will be needed to meet many of the capital costs of scaling up surgical and anaesthesia care, especially in low-income countries |
| New technologies | Scale-up of new methods was associated with major reductions in mortality, especially for the health-related MDGs. There was some focus in MICs (eg, India) on improvement of surgical technology, instruments, and manufacturing during this time | Successful product development in global health, especially in diagnostics and devices and technology, suggests substantial potential for surgical and anaesthesia care to benefit from the development and deployment of new technologies designed for LMIC environments (eg, durable, high quality, low cost, and easily repaired). This development could also permit LMICs to progress above high-income countries in terms of surgical technology |

Modified from the 2013 *Lancet* Commission on Investment in Health.[56] LMICs=low-income and middle-income countries. MICs=middle-income countries. MDG=Millennium Development Goal.

***Table 4:*** **Key enabling advances in global health as they relate to surgical and anaesthesia care: past challenges and new opportunities**

strengthening. Explicit provision for surgery within these budgets is needed, however, to ensure surgical and anaesthesia care is not overlooked, as occurs at present, and to track financing flows adequately.

Interest in use of donor money to finance country-defined programme-based approaches, rather than individual health projects, has increased.[252] Such approaches are characterised by country ownership and the coordination and harmonisation of donor activities around a comprehensive health programme that the country itself defines.[253] One popular type of programme-based approach is the sector-wide approach (SWAP), defined as an approach in which all substantial donor funding supports one comprehensive sector policy.[252] SWAPs have been applied to the health sector, including to fund surgical services,[254,255] but the results so far have been mixed.[256] For example, results of a 2012 review[257] of the evidence showed that the outcome and effect benefits of health SWAPs are inconclusive. Further assessment of the most effective mechanisms of support for comprehensive health services, including surgical services that align with country priorities, is needed.

Irrespective of the financing mechanism, to mobilise the necessary financial resources for scale-up, surgery should provide a better case for its inclusion within domestic health and external financing budgets than it has done so far. This proposition needs presentation of a clear argument for the health value of scale-up and the return on investment, and generation of political will at a national and international level, and should hold people, governments, and organisations accountable for promises made to improve surgical care (table 4).

### *Tracking of financing flows*

To improve the effectiveness of both DAH and domestic health spending, funding flow clarity and transparency is needed. In the case of surgical and anaesthesia care, reliable estimates of how much financing is needed to provide safe, accessible, and affordable surgical services at the national level, present spending on surgical and anaesthesia care, and the so-called funding gap (ie, the difference between how much financing is needed and present spending) are crucial preconditions for sound policy and decision making.

National health accounts and databases tracking overseas DAH should be redesigned to allow for comparative analyses of health systems spending by clinical intervention or service. Without the ability to track spending commitments and disbursements on surgical and anaesthesia care, countries and the international community will be unable to develop robust and transparent policy and investment strategies for scaling up surgical and anaesthesia care.

### *Improvements in payment methods for surgical and anaesthesia care*

The present scenario in LMICs, in which most of the population has to pay for surgical and anaesthesia care through user fees must be improved. Although no perfect financing system exists, three features of

surgical and anaesthesia care make prepayment mechanisms preferable to direct user fees. First, a substantial proportion of surgical disease in LMICs is time-critical and life-threatening or limb-threatening.[258,259] Second, user fees for surgical and anaesthesia care are often high, and direct payments can result in large rates of catastrophic expenditure.[243] For this reason, surgical conditions are associated with a high household poverty effect relative to other health problems.[46] Finally, emergency surgical conditions (eg, trauma and acute abdominal disorders) are not predictable, making it difficult for households to foresee or to plan for the financial outcomes.

We support the use of risk pooling to achieve financial risk protection for surgical and anaesthesia care. Risk-pooling mechanisms protect against unexpected financial shocks as a result of surgical illness and ensure that delays in care do not occur while families rally to raise funds. Options for pooling mechanisms include a supply-side approach (direct public subsidies to public facilities or zero or highly subsidised fees at the point of service for patients who need surgery or patients with a household income less than a specific amount), and a demand-side approach (the government subsidises people with a low income and those who work in the informal sector to enrol in a mandatory insurance scheme with benefit packages that include surgical and anaesthesia care). Because both social insurance models and private insurance have their drawbacks in LMICs, a desirable system might be a public insurance scheme (ideally single payer) with identical benefits for the whole population. Another option is that the government pays for people with the lowest income and those who work in informal sectors, and formal-sector workers and those with means pay their own premium.

### *Strategic purchasing and the role of the private sector*

Strategic purchasing can improve health service productivity and the quality of care in some contexts,[260] although no direct evidence exists to support its use in surgical and anaesthesia care in LMICs. In strategic purchasing, the purchaser (who can be the government or an insurance fund) selectively enters into a contract with efficient and high-quality providers with whom choices exist, irrespective of whether the providers are public or private. Payments can be complemented by an element of pay for performance, with a proportion of the fixed payment withheld and paid according to performance assessment done on a periodic basis. Performance indicators should be closely linked to process and outcome quality measures. As systems become more mature, clinical outcome metrics are preferable. Non-financial approaches to achievement of quality and efficiency improvements might also work—eg, changing of professional behaviour[66]—but virtually no studies in LMICs have compared financial and non-financial strategies, and none for surgical and anaesthesia care.[250]

The engagement of the private sector, and especially the private for-profit sector, in the delivery of health services in LMICs is controversial. Several successful examples exist in which the private not-for-profit sector has been contracted to manage hospital facilities, including surgical services, on behalf of the public sector, to increase service delivery and improve geographic coverage to a greater extent than would have been possible with government resources alone.[261] Little evidence has been reported about situations in which the contracting of private for-profit hospital services has been beneficial in LMICs. Regulatory mechanisms for all private providers, including the not-for-profit sector are often weak, making it a challenge to assure quality service delivery and to coordinate with other state actors on both short-term and long-term goals.

However, in countries with a large private for-profit sector already engaged in delivery of the bulk of surgical services, and where the public sector capacity to do so is restricted, some commentators, such as Rosemary Morgan and Tim Ensor, have proposed that a mix of public and private provision of surgical services might be a more pragmatic solution, provided its regulation is appropriate.[67] In this situation, the focus should be on development of regulatory mechanisms that promote quality and efficiency, assure equity and pro-poor financial risk protection through risk pooling, and protect against corrupt or monopolistic relationships developing between state and private actors.[67]

### *Surgery and UHC*

UHC has emerged as a leading post-2015 policy goal, supported by WHO,[262] the World Bank,[41] the UN,[42] and many governments in LMICs.[263,264] We endorse a path to UHC emphasising pro-poor progressive universalism, as laid out by the *Lancet* Commission on Investment in Health.[56] We do so on the basis that a need exists to recognise cost constraints in decisions around health coverage in LMICs, and because pro-poor pathways help promote health coverage and typically result in the greatest magnitude of health gains in LMICs.[56,264] Mexico's pathway towards UHC adopted such a pro-poor approach.[265] Assessments of the Mexican health reform suggest that it has improved access, equity, and uptake of services, and was associated with an unprecedented increase in surgical volume in the country, at an average rate of 23% per year. Whether pro-poor progressive universalism is best achieved through the targeting of poor people by the choice of surgical interventions covered or through fee exemptions for surgical and anaesthesia care is unclear. Results of research in Mexico and Thailand suggest both methods can work and both have advantages and disadvantages.[56,265,266]

### *Panel 5:* Multicriteria decision analysis for funding surgical procedures, packages, and platforms within progressive universalism schemes

Thought should be given to the following factors, using country-specific data and contexts:

- Size of the population affected by the disease
- Severity of the disease, including chance of death or permanent disability if untreated and including level of impairment
- Effectiveness of the surgical intervention, including chance of cure with the intervention and ability to be done successfully within the skill and resource level of the country
- Economic effect of the condition on the household, including catastrophic expenditure and effect on productivity
- Welfare effect of the condition on the household, including effects on primary caregiver and on schooling and welfare of dependants
- Equity and social implications and the extent to which it is a pro-poor policy
- Cost-effectiveness of the particular procedure and the platform needed for delivery
- Budget implications of coverage, including necessary expenditure to provide the intervention to all those who need it

### *Panel 6:* Core packages for surgical and anaesthesia care

The packages listed here would be appropriate to provide within the initial coverage and benefits package under universal health coverage, with examples of procedures each package might cover. Individual countries should perform their own decision analyses to tailor the procedures, packages, and platforms according to their individual needs. The multicriteria decision analysis framework, outlined in panel 4, was applied to a series of surgical procedures and packages to generate this list.

**Common conditions: emergency procedures**

*Basic trauma surgery package*

- Open and closed fracture repair, chest tube placement, amputation, trauma laparotomy, burr hole, wound care, debridement.

*Basic emergency obstetric surgical package*

- Caesarean section, hysterectomy, salpingectomy, dilatation and curettage.

*Basic emergency general surgical package*

- Laparotomy, appendectomy, hernia repair with or without bowel resection, incision and drainage of soft tissue infections.

**Common conditions: planned care packages**

*General surgical package*

- Hernia repair (non-obstructed or incarcerated), hydrocelectomy, cholecystectomy, ureteric or kidney stone removal, prostatectomy, thyroidectomy (goitre-endemic regions), excision biopsy, lumpectomy or mastectomy, resection of early-stage oral cavity tumours, bowel resection.

*Obstetric and gynaecological package*

- Treatment of cervical pre-cancerous lesions, hysterectomy for invasive cervical cancer.

*Specialist surgical package*

- Cataract repair, trachoma surgery (where endemic), cleft palate and lip repair, clubfoot correction, surgical repair of congenital heart anomalies, obstetric fistula repair.

*Palliative surgical care package*

- Mastectomy, diversion colostomy; palliative surgical care packages should be delivered alongside access to appropriate palliative analgesics, including opioids.

Irrespective of the mechanisms by which an individual country moves towards UHC, we believe a basic level of surgical and anaesthesia care should be included as part of the initial coverage package within a country's UHC expansion pathway. As we have shown in this report, although surgical and anaesthesia care can improve health and fight poverty in LMICs, use of surgical and anaesthesia care can also be impoverishing for households in the absence of effective coverage and financial risk protection.

Four levels of surgical coverage exist, conveniently denoted as the 4Ps: the procedures that are covered; the packages of surgical and anaesthesia care in which different procedures are grouped, funded, and purchased; the platforms on which packages of surgical and anaesthesia care are delivered (community health centre, first-level hospital, second-level hospital, etc); and the national and international policies that assure universal coverage and that inform how this coverage is organised and delivered.

Under the scenario of progressive universalism, by definition, not everything can be funded immediately. The most cost-effective interventions and those that are associated with the highest levels of impoverishment in the absence of financial risk protection are typically given priority in the initial benefits package. Other factors can also be included in decisions about what to cover, according to a country's specific context, values, and political environment. In panel 5 we outline factors that are important for countries to consider when deciding which surgical procedures, packages, and platforms to include within their coverage policies. These factors are not exhaustive, but can be used as a guide to assist policy makers, health planners, and ministries of health and finance in their decision making.

By applying these criteria to a typical LMIC and with emphasis on targeting people of low income through the choice of interventions that will benefit them most, we present one potential set of core surgical procedures, packages, and platforms that might form the first step in a surgical coverage policy under a progressive universalism path (panel 6; appendix p 133).

## Recommendations for economics and financing

*National (governments, ministries of health, ministries of finance)*

- UHC policies should include surgery and cover basic packages of surgical and anaesthesia care from early within the expansion pathway.
- Health financing mechanisms for surgical and anaesthesia care that are based on risk pooling should be used instead of user fees at the point of care. Risk pooling with one pool and payer (eg, a public national health insurance) can improve equity, access, and financial risk protection.
- Increased mobilisation of domestic health financing sources towards surgical and anaesthesia care is needed to meet the costs of scaling up surgical and anaesthesia services to a minimally acceptable level. Early investments will pay the greatest dividends in terms of health benefits and economic and welfare gains.

- Improved tracking of financing flows to surgical services through national health accounts is needed. Disaggregated accounting and improved transparency will assist with improved tracking of financial flows. Strategic purchasing—ie, risk-pooled funds for surgical services that pay providers on the basis of quality output and outcomes—should be further explored as a means of improving quality and efficiency.

*International (World Bank, WHO, USAID, OECD, Eurostat)*

- Surgical and anaesthesia care should be included within UHC policies and goals.
- Increased international health financing (eg, traditional DAH and innovative global health financing) is needed to finance the scale-up of surgical services in many LMICs, particularly for capital costs. Financing of health systems strengthening in LMICs should explicitly include surgical services.
- Tracking of financing flows to surgery within global DAH or Overseas Development Assistance databases is needed. Increased transparency and disaggregation of spending within DAH accounts will assist with tracking efforts.
- The international System of Health Accounts (which outlines statistical reporting rules for financial data provided by national health accounts, allowing for international comparisons of health-care spending between countries) should include and collect surgical data to allow for standardised reporting of expenditure on surgical and anaesthesia care and its financing. Surgical and anaesthesia care should be included within the International Classification for Health Accounts health care, health providers, and health financing tables.
- Increased attention should be given to the use of innovation and technology to reduce costs and optimise the use of resources in the delivery of surgical and anaesthesia care in low-resource environments.

## Information management

### Data for monitoring and generating progress

Data collection, analysis, and reporting of findings are crucial for a responsive and effective health-care system. Consistent monitoring of data through a limited set of indicators, such as those used for the MDGs, can focus attention and galvanise support about a particular topic. Here, we examine what global health information is collected and used for surgery. We then use these findings to develop and propose a core set of surgical indicators to be used at national and international levels to monitor progress towards universal access to safe, affordable surgical and anaesthesia care when needed.

### The present situation

*Data collection*

Mechanisms for acquisition of health-specific data vary depending on the level of collection, desired use, and resource availability. These approaches have been broadly grouped into population-based and facility-based methods. Additional sources are administrative data, such as from accreditation and licensing bodies and modelling.

Population-based mechanisms for health monitoring include civil registration systems, censuses, demographic surveillance systems, verbal autopsies, and household surveys or questionnaires. Country-wide documentation of medically certified cause of death and births through civil registration and vital statistics systems is the gold standard for mortality statistics and subsequent knowledge of many health issues. However, to develop the infrastructure necessary to collect these data is time and resource intensive. Few countries maintain complete civil registration and vital statistics systems;[18] only 1% of deaths are reported by cause in low-income countries.[17] Notwithstanding a host of moral, legal, and policy implications, this so-called scandal of invisibility greatly hinders true understanding of (let alone ability to affect) cause, magnitude, and effect of deaths from any condition, including those of a surgical nature.[19] As discussed earlier, most of what is known about the burden of surgical conditions is therefore based on modelling methods, or limited data samples generated through the methods we describe in this section.

Household surveys are one method to generate epidemiological data. Such surveys frequently include various demographic, socioeconomic, health, and financial states.[27] Household surveys are typically funded externally in the lowest-resource settings and are expensive to undertake,[268–270] and have been used for years to examine health factors on subnational, national, and multinational scales. Different surveys are used in different countries with varying frequencies. To assess inclusion of surgical conditions within household surveys, we reviewed four of the most widely used multinational surveys: Multiple Indicator Cluster Surveys (MICS), Demographic and Health Surveys (DHS), Living Standards Measurement Study (LSMS), and the World Health Survey (WHS). Full methods are reported in the appendix (p 136) and results in table 5.

For **key findings from the information management working group** see appendix p 135

Briefly, MICS were originally created by UNICEF as monitoring methods for various indicators of child welfare after the 1990 World Summit for Children.[271] Since inception, the surveys have been completed in more than 100 countries and are in the fifth iteration, MICS5.[272] The only MICS5 indicator identified that pertains directly to surgery is indicator 5·9, which assesses birth by caesarean delivery.

The DHS Program, funded by USAID, institutes country-wide data collection pertaining to population, health, and nutrition. Introduced in 1984, the DHS Program has overseen completion of surveys in more than 90 countries.[273] The present version, DHS6, has a strong maternal child health focus and basic surgical inclusion: birth by caesarean delivery and OOP expenditures for accidents or injuries and births.

| | Question location or category |
|---|---|
| **Demographic and health surveys (DHS6)** | |
| What was the main reason to seek care? Options: accident/injury; pregnancy/delivery (Q 206, 210, 214, and 305) | Out-of-pocket Health Expenditures Module |
| Was [baby] delivered by caesarean? (Q 435) | Model Woman's Questionnaire |
| Have you sought treatment for this condition? Did you have an operation to fix the problem? (Q F7, F10) | Fistula Module |
| Did [mother] die during childbirth? (Q MM11) | Maternal Mortality Module |
| **Living Standards Measurement Study (LSMS Malawi 2013)** | |
| During the past 2 weeks have you suffered from an illness or injury? (Q D04) | Module D: Health |
| What was the illness or injury? Options: stomach ache; burn; fracture; wound; other (Q D05) | Module D: Health |
| How much in total did you spend in the past 4 weeks for all illnesses and injuries? (Q D10) | Module D: Health |
| What chronic illness do you suffer from? Options: stomach disorder; sores that do not heal; cancer; other (Q D34) | Module D: Health |
| **Multiple indicator cluster surveys (MICS5)** | |
| Was [baby] delivered by caesarean section? (Q MN19) | Questionnaire for Individual Women |
| When was the decision made to have the caesarean section? Was it before or after your labour pains started? (Q MN19) | Questionnaire for Individual Women |
| Why do you think you are not physically able to get pregnant? One choice: hysterectomy (Q UN11) | Questionnaire for Individual Women |
| **World Health Survey (long version: individual questionnaire)** | |
| Was the death associated with injury? (Q 5203) | Mortality—Verbal Autopsy |
| Provide details of events that led to the injury. What was the mechanism or cause of injury? (Q 5205) | Mortality—Verbal Autopsy |
| Where did the injury occur? (Q 5206) | Mortality—Verbal Autopsy |
| When was the last time you had a pelvic examination, if ever? (Q 6300) | Coverage—Cervical Cancer and Breast Cancer Screening |
| The last time you had the pelvic examination, did you have a PAP smear test? (Q 6301) | Coverage—Cervical Cancer and Breast Cancer Screening |
| When was the last time you had a mammography, if ever? (Q 6302) | Coverage—Cervical Cancer and Breast Cancer Screening |
| Who did you see most of the time? One option: doctor (including specialists such as a gynaecologist, obstetrician, surgeon, etc) (Q 6402) | Coverage—Maternal Health Care |
| When you gave birth to [baby], who assisted in the delivery? Option: doctor (including specialists such as a gynaecologist, obstetrician, surgeon, etc) (Q 6410) | Coverage—Maternal Health Care |
| In the last 5 years, have you had eye surgery to remove your cataracts? (Q 6702) | Coverage—Vision Care |
| Dental work or oral surgery? (Q 6753) | Coverage—Vision Care |
| In the past 12 months, have you been involved in a road traffic accident where you suffered from bodily injury [or] suffered bodily injury that limited your everyday activities? (Q 6800, 6806) | Coverage—Care for Road Traffic and Other Injuries |
| When (in the last 12 months) did the accident happen? (Q 6801, 6807) | Coverage—Care for Road Traffic and Other Injuries |
| Did you receive any medical care or treatment for your injuries? (Q 6802, 6808) | Coverage—Care for Road Traffic and Other Injuries |
| Where did you first receive care? (Q 6803, 6809) | Coverage—Care for Road Traffic and Other Injuries |
| Was it government operated or private? (Q 6804, 6810) | Coverage—Care for Road Traffic and Other Injuries |
| How soon after the traffic accident or injury occurred did you first receive care? (Q 6805, 6811) | Coverage—Care for Road Traffic and Other Injuries |
| Which reason best describes why you/your child last needed health care? Options: bodily injury; minor surgery (Q 7003) | Health System Responsiveness—Inpatient Hospital |
| Which of the following best describes the reason for your /child's/ last overnight stay? Options: bodily injury; minor surgery (Q 7403) | Health System Responsiveness—Needing Health Care and General Evaluation of Health Systems |

The content in parenthesis pertains to the actual question numbers of the relevant questions in those surveys.

*Table 5:* **Identification of questions pertaining to common surgical conditions or treatment within four multinational household surveys**

In 1980, the World Bank developed LSMS in an attempt to enhance household data collected in developing countries and guide policy decisions.[274] LSMS can be modified to fit the needs of the country in which it is being used and thus far has been administered 104 different times in 36 different countries.[275] Review of the 2013 Malawi version of LSMS identified only a few surgically focused questions that asked about the presence of injuries, wounds, and malignancies.

The WHO's WHS was a one-time effort to collect data for adult population health and health systems. 70 countries participated during the implementation period (2002–04). Of the four multinational household surveys discussed, the WHS has the greatest number of surgically focused questions, including questions about cancer screening, vision care, and injuries. Injury-specific questions were detailed, inquiring how the injury was obtained, whether and from where care was received, and in what timeframe (table 5).

Several surgery-specific household surveys have also been created to assess burden of surgical conditions (appendix p 136).[276–280] However, several limitations hinder the surveys' ability to generate accurate estimates of disease prevalence. Surveys are frequently incomplete assessments and either do not have clinical validation, or have poor sensitivity in identification of disease. Linden and colleagues[281] were the first to validate, using physical examination, a method to assess the presence of

congenital and general surgical conditions. The ability to identify true disease, however, was insufficient, with a sensitivity of 44·5% and specificity of 97·7% (appendix p 137).[281]

Various additional population-based methods for disease monitoring are gaining popularity and could be used more widely to monitor surgical conditions. Verbal autopsy is one such method that acquires substantial traction for public health use. Although documented inclusion of surgical conditions has largely been restricted to trauma, cancer, and obstetric conditions,[282–286] the Million Death Study has used it to assess acute abdominal disorders (appendix p 136).[259] Finally, demographic surveillance systems are another mechanism of epidemiological monitoring that can collect information about surgical conditions. Although not yet used widely to track surgical disease,[287] demographic surveillance systems have been used to survey maternal disorders, and potential exists for more widespread application.

Although population-based data collection often focuses on condition prevalence, facility-based health data (gathered via facility surveys, patient charts, hospital files, logbook reviews, police records, and transport documents) can provide information about facility availability, preparedness, and care provided.

Many facility assessments exist, including surgery-specific assessments and more broadly focused facility surveys with surgical subcomponents (appendix p 138). These surveys collect varying information about the presence of equipment, supplies, infrastructure components, workforce members, and procedures undertaken. Many facility assessments are also completed using unpublished methods (appendix p 138). However, the combination of frequently incomplete, non-existent, or inaccessible point-of-care records (combined with inconsistent data collection methods), absence of survey validation, and weak inter-user reliability generates concern that these surveys are more like key informant interviews rather than mechanisms for accurate facility appraisals.[288,289] Additionally, evidence that survey findings are applied to generate change is scarce, calling into question the aim, use, and effectiveness of these assessments.[290]

There is a dearth of uniformly collected data at population or facility levels pertaining to surgical conditions or care in LMICs. When surgical components are included in disease surveillance systems, they typically focus on trauma, birth by caesarean delivery, and less often on cancer. Absence of uniformly used methods to monitor surgical conditions or delivery of surgical and anaesthesia care restricts comparability of data that do exist. And use of unvalidated instruments calls into question the accuracy of results generated. This gap in reliable data greatly hinders knowledge of burden and ability to monitor change, track interventions, or build robust advocacy and funding platforms. Additionally, inappropriate allocation of resources and policy decisions could occur if inaccurate results from unvalidated methods are used to inform health service decisions.

### *Data compilation: registries and databases*

Various tools, such as disease-specific registries, can aid in data storage, organisation, and analysis. Collation of health data through registries has occurred for centuries with documentation of cancer registry attempts dating back to the 1700s.[291] Surgically focused registries range from local or national registries instituted and owned by hospitals or governments, such as the Malawi Arthroplasty Registry (panel 7), to international databases, such as the NGO-maintained SIGN Online Surgical Database.

Use of registry data can provide a concise and valuable mechanism for public health surveillance and improvement in patient care. For example, trauma registries have become important components of many trauma systems,[292] providing a basis for quality improvement, affecting perceptions of the problem of injury, shaping resource flows, and documenting system gains such as morbidity and mortality reductions.[292,293] However, concerns ranging from issues of funding to feasibility and sustainability, and data use and ownership and database maintenance, are common.[294,295]

To further highlight examples of LMIC registries and databases, including use, benefits, and complications, we have included two registry examples from our own experience (panel 7; appendix p 139) and two approaches to outcomes and quality monitoring via the Commission's teaching cases: Mozambique's National Surgical Quality Improvement Program (NSQIP)-lite and Uganda's Surgical Quality Assurance Database (SQUAD).

### *Coding surgical conditions and treatments*

Collection, analysis, comparison, and reporting of surgical data can be assisted with a standardised coding system. In 1839, William Farr, a British medical statistician, wrote "the advantages of a uniform statistical nomenclature, however imperfect, are so obvious, that it is surprising no attention has been paid to its enforcement".[296] In terms of the global coding of surgical conditions and interventions, however, William Farr's lamentations about absence of an internationally used system still hold true, despite previous statements as to its need and feasibility.[11]

Many previous medical coding systems have been developed and suggested. The International Classification of Diseases (ICD) is the most widely used mechanism for coding morbidity and mortality. Used in more than 100 countries, the ICD has been translated into 36 different languages, and WHO has supported its use since 1990.[297,298] Alternative coding frameworks have also been developed, including the International Health Terminology Standards Development Organisation's (IHTSDO) increasingly popular Systematized Nomenclature of Medicine clinical terminology (SNOMED CT). SNOMED

### *Panel 7:* The Malawi arthroplasty registry: a surgery-specific registry

**Why it was created**

The volume of joint-replacement surgery in sub-Saharan Africa is increasing. Evidence shows that the profiles of patients needing arthroplasty and the indications for surgery in this region are different from those in developed countries. In Malawi, new centres with variable standards of care and surgical providers with variable levels of training are doing arthroplasty. In 2006, to formally audit this work and assess arthroplasty indications and outcomes, the Malawi Government initiated a registry of information about all joint replacements done in the country. Using the Malawi experience as a pilot, other countries will hopefully follow suit with the goal to establish a regional arthroplasty registry.

**What is included**

Data collected includes age, sex, indication for surgical procedure, type of prosthesis used, surgical approach, use of bone graft, type of cement, pressurising systems, thromboprophylaxis used, complications, and clinical outcomes. All patients have clinical scores recorded preoperatively, after 3 and 6 months, and then at 1 year postoperatively. Before surgical procedures, all patients are counselled and consent to an HIV test, allowing analysis of the effect of HIV on indications for and outcomes of joint replacement. All data are recorded prospectively, although a few cases done before establishment of the registry were added retrospectively. The data will be mined periodically to look at specific variables for research publications. So far, 252 total hip replacements and 146 total knee replacements have been included.

**Why it is beneficial**

The registry has already revealed interesting findings on arthroplasty in Malawi. For example, the most common indication for hip arthroplasty is avascular necrosis of the femoral head with a mean age of 55 years. The most common indication for total knee replacement is osteoarthritis with a mean age of 64 years. HIV infection seems to play a substantial part in indications for total hip replacement. The complication profiles for infection and deep-vein thrombosis are similar to those in developed countries. Overall, results suggest that arthroplasty can be done safely in sub-Saharan Africa, although the indications for surgery and patient profile are very different from those in high-income countries.

CT contains more than 100 000 clinical terms (compared with ICD, 10th revision, clinical modification's 68 000 diagnostic codes), describes relations between data groups (compared with ICD's listing of clinical terms), and allows for detailed searches using many filters.[298] Proponents of SNOMED CT suggest that it should be used for electronic medical records, whereas ICD should be reserved for administrative use and reporting.[298] Working arrangements have been made between the IHTSDO and WHO to establish maps and links between the two systems.[298]

With concrete, systematised information about surgical conditions and treatments, a host of improvements could transpire. By understanding met and unmet need for surgical care, the world could better plan necessary interventions. Universally used coding systems for surgical disease and treatment could expand opportunities for local and international collaborations on research and quality improvement efforts. Assessment of conditions seen and treated during natural disasters or times of conflict could improve deployment of resources in similar environments. Development and implementation of a universal classification system for health interventions (including surgery) that can function as an international and multilingual reference standard is crucial for proper quantification and characterisation of all conditions, including those of a surgical nature.

*Data use: current global surgery indicators*

Measured and reported activities are the ones that garner the most attention. To turn data into credible and widely used indicators can be incredibly helpful for generation of political action and subsequent health improvements.[299,300] Consider the advances seen in the context of MDG indicators, such as maternal mortality ratio, infant mortality rate, and HIV prevalence.[299,300] In nearly all regions of the world, burden of disease related to MDGs 4, 5, and 6 has declined,[10] suggesting a positive and productive health effect on topics associated with identification as an MDG priority. In contrast, many diseases not included within the MDGs, such as most surgical conditions, did not achieve similar improvements.

Several indicators have previously been proposed to monitor surgical conditions or the delivery of surgical and anaesthesia care.[301–304] However, none have gained traction to become broadly used measures. To formally assess which surgical indicators are reported worldwide, we queried publically available major global health indicator databases. With surgical and anaesthetic keywords, we interrogated the WHO Indicator and Measurement Registry, the WHO Global Health Observatory, the World Bank data website, and UNICEF's data page. For comparison with topics that have gained more political traction than has surgery, we also searched the databases using non-surgical keywords (figure 14; appendix p 140).

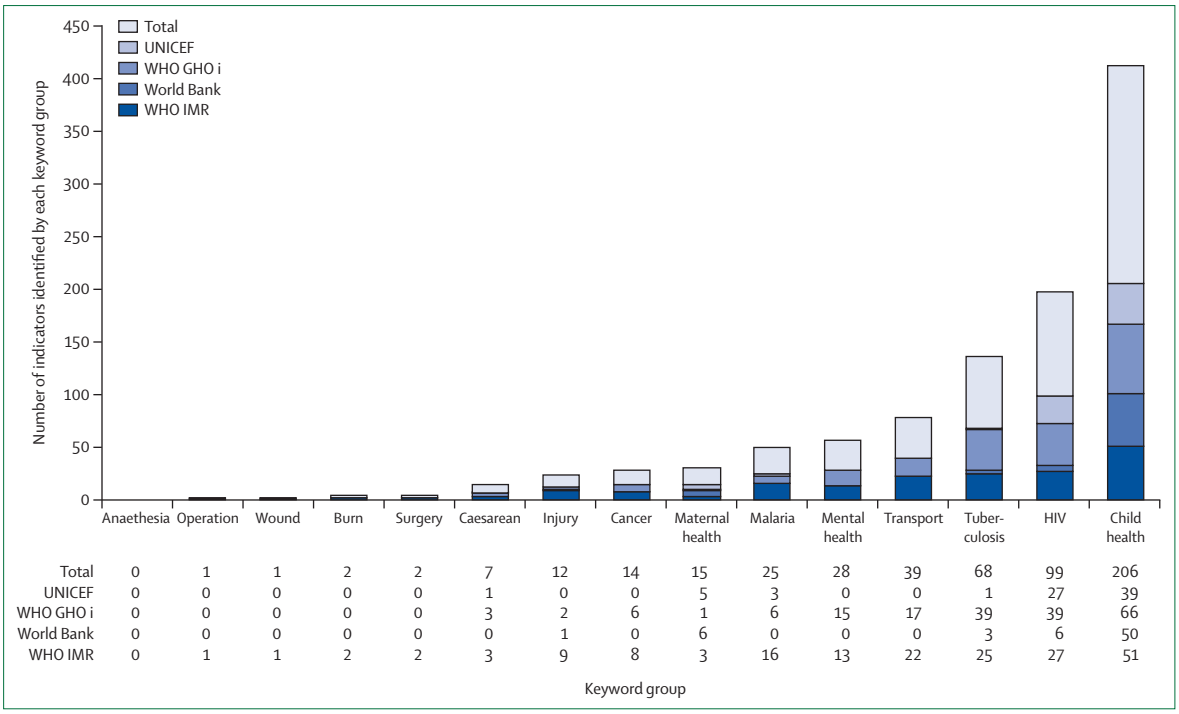
Surgical keywords identified substantially fewer indicators than non-surgical keywords. Of the surgical keywords, indicators related to road safety and transport were most prevalent. Indicators related to cancer were the next most common, followed by those pertaining to injury and then caesarean delivery. With the exception of births by caesarean delivery and rate of surgical wound infection, none of these indicators relate directly to the provision of surgical and anaesthesia care.

## The way forward

*Proposed global surgery indicators*

Our vision of the *Lancet* Commission on Global Surgery is universal access to safe, affordable surgical and anaesthesia care when needed. Here we present a suite of core indicators to monitor progress towards this goal.

Building on findings presented earlier in this section, we convened a working group charged with indicator development (appendix p 142). In 2009, a set of metrics for surgical surveillance were defined as part of the WHO Safe Surgery Saves Lives initiative.[301] However, little adoption of their use has occurred. We built on these metrics to create a set of core indicators to monitor universal access to safe and affordable surgical and anaesthesia care by using new




| | Anaesthesia | Operation | Wound | Burn | Surgery | Caesarean | Injury | Cancer | Maternal health | Malaria | Mental health | Transport | Tuber-culosis | HIV | Child health |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0 | 1 | 1 | 2 | 2 | 7 | 12 | 14 | 15 | 25 | 28 | 39 | 68 | 99 | 206 |
| UNICEF | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 3 | 0 | 0 | 1 | 27 | 39 |
| WHO GHO i | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 6 | 1 | 6 | 15 | 17 | 39 | 39 | 66 |
| World Bank | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 0 | 0 | 0 | 3 | 6 | 50 |
| WHO IMR | 0 | 1 | 1 | 2 | 2 | 3 | 9 | 8 | 3 | 16 | 13 | 22 | 25 | 27 | 51 |

***Figure 14:*** **Frequency of select surgical and non-surgical keywords identified in health indicators from global health indicator databases**
For each of the keyword groups presented in the figure, the following variations of the terms were identified: Anaesthesia=anaesthesia, anesthesia; Operation=operat*; Wound=wound; Burn=burn; Surgery=surg*; Caesarean=c-section, caesarean, cesarean; Injury=trauma, fall, accident, injur*; Transport=road, transport; Cancer=cancer, malignancy, tumour, neoplasm; HIV=HIV; Tuberculosis=TB, tuberculosis; Malaria=malaria; Child health=child; Maternal health=maternal; Mental health=mental. WHO GHO i=WHO Global Health Observatory, search by indicator. WHO IMR=WHO Indicators and Measurement Registry. World Bank=World Bank data website. UNICEF=UNCIEF data page.

research to better understand their use. We considered the present environment of global health priorities and politics to maximise uptake and feasibility, and integrated a strong equity focus to combat current inequities in surgical and anaesthesia care delivery and to prevent uneven future improvements, such as seen with the MDGs.[305] Our indicators apply to a broad range of conditions and operations, and are intended to be collected at a national level (initially by the responsible entity identified in table 6) and reported at a global level.

Many frameworks for organisation of health indicators exist, such as input-output-outcome-impact and structure-process-outcome frameworks. However, no frameworks fully capture the heavy human toll of untreated surgical conditions or fully encompass the event-based aspects of surgery, including its facility dependence and need for specialised equipment and supplies. We therefore developed a three-group framework to organise and assess our surgical indicators (panel 8).

The Commission's core indicators are listed in table 6. The intent is for the indicators to be used in tandem. We briefly discuss each indicator below, including components, rationale, feasibility, and time-bound targets. We delineate equity stratifiers and additional disaggregates deemed feasible and necessary for reporting of indicators. We also identify optional disaggregates for more advanced monitoring systems (such as those in middle-income countries or for future goals).

### *Access to timely essential surgery*

The first indicator—access to timely essential surgery—is of temporal access to essential surgical and anaesthesia care. The indicator is defined as the proportion of the population that can reach, within 2 h, a facility capable of doing the Bellwether Procedures. Equity stratifiers include residence (urban or rural) and wealth quintile of the population. Additional disaggregates include facility type and facility ownership (public or private).

Global access to safe, timely, and affordable surgical and anaesthesia care is grossly inadequate,[29] resulting in a large unmet need for procedures.[27] The Bellwether Procedures serve as a proxy of systems, resources (both human and physical), and skill sets needed to treat a broad range of essential surgical conditions. Use of the Bellwether Procedures within this indicator is therefore not merely to capture treatment of conditions needing those procedures, but rather to more broadly measure the presence of functioning, comprehensive care delivery platforms.

2 h was chosen because it is a rough time from onset of bleeding to death in post-partum haemorrhage if intervention is not provided.[23] Use of the 2 h timeframe does not imply that all surgical conditions need to be

| | Definition | Rationale | Data sources | Responsible entity | Comments | Target |
|---|---|---|---|---|---|---|
| **Group 1: Preparedness for surgical and anaesthesia care** | | | | | | |
| Access to timely essential surgery | Proportion of the population that can access, within 2 h a facility that can do caesarean delivery, laparotomy, and treatment of open fracture (the Bellwether Procedures) | All people should have timely access to emergency surgical services; Bellwether Procedure performance predicts accomplishment of many other essential surgical procedures; 2 h is a threshold of death from complications of childbirth | Facility records and population demographics | Ministry of Health | Informs policy and planning about location of services in relation to population density, transport systems, and facility service delivery | A minimum of 80% coverage of essential surgical and anaesthesia services per country by 2030 |
| Specialist surgical workforce density | Number of specialist surgical, anaesthetic, and obstetric physicians who are working per 100 000 population | The availability and accessibility of human resources for health is a crucial component of surgical and anaesthesia care delivery | Facility records, data from training and licensing bodies | Ministry of Health | Informs workforce, training, and retention strategies | 100% of countries with at least 20 surgical, anaesthetic, and obstetric physicians per 100 000 population by 2030 |
| **Group 2: Delivery of surgical and anaesthesia care** | | | | | | |
| Surgical volume | Procedures done in an operating theatre, per 100 000 population per year | The number of surgical procedures done per year is an indicator of met need | Facility records | Facility, Ministry of Health | Informs policy and planning about met and unmet need for surgical care | 80% of countries by 2020 and 100% of countries by 2030 tracking surgical volume; 5000 procedures per 100 000 population by 2030 |
| Perioperative mortality | All-cause death rate before discharge in patients who have had a procedure in an operating theatre, divided by the total number of procedures, presented as a percentage | Surgical and anaesthesia safety is an integral component of care delivery; perioperative mortality encompasses deaths in the operating theatre and in the hospital after the procedure | Facility records and death registries | Facility, Ministry of Health | Informs policy and planning about surgical and anaesthesia safety and surgical volume when number of procedures is the denominator | 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 |
| **Group 3: Effect of surgical and anaesthesia care** | | | | | | |
| Protection against impoverishing expenditure* | Proportion of households protected against impoverishment from direct out-of-pocket payments for surgical and anaesthesia care | Billions of people each year are at risk of financial ruin because they have accessed surgical services; this is a surgery-specific version of a World Bank universal health coverage target | Household surveys, facility records | World Bank, WHO, USAID | Informs policy about payment systems, insurance coverage, and balance of public and private services | 100% protection against impoverishment from out-of-pocket payments for surgical and anaesthesia care by 2030 |
| Protection against catastrophic expenditure† | Fraction of households protected against catastrophic expenditure from direct out-of-pocket payments for surgical and anaesthesia care | Billions of people each year are at risk of financial ruin because they have accessed surgical services; this is a surgery-specific version of a World Bank universal health coverage target | Household surveys, facility records | World Bank, WHO, USAID | Informs policy about payment systems, insurance coverage, and balance of public and private services | 100% protection against catastrophic expenditure from out-of-pocket payments for surgical and anaesthesia care by 2030 |

Access, workforce, volume, and perioperative mortality indicators should be reported annually. Financial protection indicators should be reported alongside the World Bank and WHO measures of financial protection for universal health coverage. USAID=US Agency for International Development. Equity stratifiers listed in discussion. *Impoverishing expenditure is defined as being pushed into poverty or being pushed further into poverty by out-of-pocket payments.[43] †Catastrophic expenditure is defined as direct out-of-pocket payments of greater than 40% of household income net of subsistence needs.[306] These indicators provide the most information when used and interpreted together; no single indicator provides an adequate representation of surgical and anaesthesia care when analysed independently.

***Table 6*: Core indicators to monitor realisation of universal access to safe, affordable surgical and anaesthesia care when needed**

treated within 2 h, because the crucial window for morbidity and mortality reduction from time-critical conditions might be shorter or longer depending on the patient and the condition. Rather, this method represents a target timeframe, based on a common, essential, and time-critical condition, within which people should have access to a health-care facility capable of essential surgical and anaesthesia care.

Although Euclidean distance has been the traditional measure of geographic access,[307] it does not address contributing factors such as mode of transport and geographic terrain.[308] Advancing technology and increasingly available geospatial data allow for more accurate and feasible temporal measures of geographic access.[309] We have successfully shown the feasibility of using such approaches to measure what proportion of the population have access to emergency surgery within 2 h in nine countries.[155]

Our target of at least 80% coverage of essential surgical and anaesthesia services per country by 2030 is necessary to reach the World Bank and WHO target of 80% access to essential health services by 2030.[39]

### *Specialist surgical workforce density*

The second indicator—surgical workforce density—is an indicator of surgical workforce availability. The indicator is defined as the number of specialist surgical, anaesthetic, and obstetric providers who are working per 100 000 population. Equity stratifiers include location (urban or rural) of place of work. Disaggregates include physician cadre (surgical, anaesthetic, or obstetric). Disaggregates for more advanced monitoring systems

include all cadres of the surgical, anaesthetic, and obstetric surgical workforce (specialist physicians, non-specialist physicians, and non-physician clinicians), level of training completed (degree), whether the provider is licensed (yes or no), and details of work location (facility type and facility ownership [public or private]).

Surgical and anaesthesia care cannot be delivered without a surgical workforce. This Commission delineates the large gap (worldwide shortage of 1·1 million using the 40 SAO per 100 000 population threshold specialist surgical, obstetric, and anaesthetic providers) and inequity in distribution of the surgical workforce in LMICs. Ability to monitor graduation from accredited training programmes and licensing by national or regional licensing bodies is ideal; however, such regulation does not exist in many countries. To capture providers who are actually working is important, because many registers contain providers who have retired, emigrated, or become inactive and are therefore not contributing to care delivery.

WHO already tracks health worker numbers (physicians, nurses, and midwives). We have shown the gross feasibility of additional stratification by tracking specialist surgical, anaesthetic, and obstetric physicians in this report through collection of data from 167 of 194 WHO member countries.[151]

The density of 20 specialist physicians per 100 000 population is based on the positive correlation between workforce density and maternal survival and surgical volume that we have discussed in this report. A specialist surgical workforce density of less than 20 per 100 000 is associated with a substantial decrease in maternal survival. Workforce density needs, and therefore ideal target numbers, will vary per region. Therefore, 20 specialist physicians per 100 000 population is not an endpoint, but rather an interim density for acceptable access to essential surgical and anaesthesia care that should be reassessed in 2030 on the basis of available data. Individual countries should define their ideal surgical workforce density to meet the needs of their population.

*Surgical volume*

The third indicator—surgical volume—is of met need for surgical and anaesthesia care. It is defined as the number of procedures undertaken in an operating theatre per 100 000 population per year. A procedure is defined as the incision, excision, or manipulation of tissue that needs regional or general anaesthesia, or profound sedation to control pain.[301] Equity stratifiers include residence (urban or rural), sex (male or female), and wealth quintile of the population. Disaggregates for more advanced monitoring systems include case mix (procedure name), admission diagnosis, case urgency (planned or emergency), and patient risk stratifiers (age and American Society of Anaesthesiologists [ASA] score), and location that the procedure was done (facility type and facility ownership [public or private]).

As discussed earlier, at least 143 million additional surgical procedures are needed in LMICs each year to save lives and prevent disability. However, optimum surgical rates vary substantially from one region to the next depending on epidemiology and previous access to care.[27] Each country should therefore define its ideal surgical rate and case mix to meet population needs.

Case mix documentation is important for several reasons: first, some types of procedures are more crucial to the health and wellbeing of a population than others; second, some procedures, such as caesarean delivery, are overdone in some regions; and third, patients with increased risk for mortality because of premorbid factors or procedure complexity do not receive needed operations owing to a shortage of resources or realistic fear of retaliation from poor outcomes.

Although surgical volume captures met need, it is not a measure of total need. In an ideally functioning health system, access would be at 100%, all patients would receive the care they need, and therefore met need captured in clinical records would represent total need. In reality, unmet need is large,[27] most prevalence estimates for surgical conditions are modelled, and uniform, clinically validated methods to assess burden in the population do not exist. Development and validation of such methods was beyond the time-scope of this Commission. However, future research should be done to identify accurate methods of tracking the prevalence of surgical conditions, and such work should lead to an indicator for unmet need.

Data for surgical volume are likely to exist at a facility level, because documentation of procedures done in theatre logbooks is a very common practice in many settings.[309] Additionally, surgical volume was the most widely reported surgical indicator by LMICs in the scientific literature (appendix p 144).

***Panel 8:* Global surgery indicator framework**

**Group 1: Preparedness for surgical and anaesthesia care**

These indicators relate to access measures such as the geographic location of facilities, infrastructure and supply measures such as the availability and readiness of necessary facilities and equipment, and workforce measures such as the availability of suitably trained personnel. These indicators provide information about whether services are appropriately planned and sufficiently developed to enable the delivery of universal access to safe, affordable surgery when needed.

**Group 2: Delivery of surgical and anaesthesia care**

These indicators measure effective coverage, which is the extent to which surgical and anaesthesia care is being provided to people who need it, and the quality of care that is being provided. These indicators provide information about the extent to which universal access to safe, affordable surgery is being provided when needed.

**Group 3: Financial impact of surgical and anaesthesia care**

These indicators measure intended outcomes such as change in the avertible burden of disease, life expectancy, and productivity, and unintended outcomes such as catastrophic expenditure or impoverishment due to surgery. These indicators provide information about the effect of realisation (or absence of realisation) of universal access to safe, affordable surgery when needed.

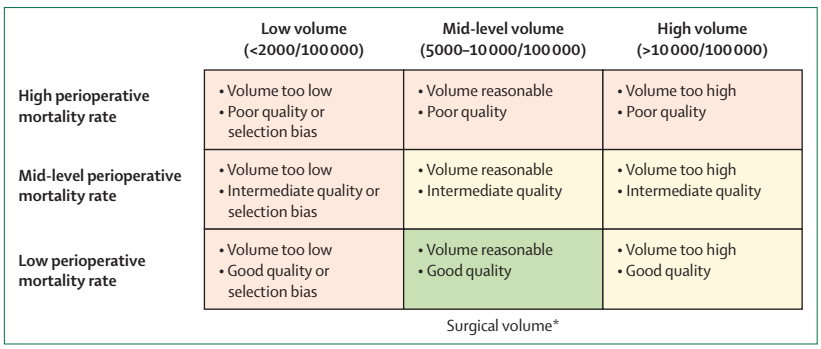



***Figure 15:*** **National surgical volume and perioperative mortality analysis matrix**
Red shows areas of high concern, yellow shows areas of moderate concern, and green shows areas of desired targets. Selection bias can be identified with country level data collection that includes risk stratification and surgical procedure coding. This is important and will require enhanced information management capabilities, but should not preclude the immediate collection of perioperative mortality rate and surgical volume.

Our first surgical volume target is that 80% of countries by 2020 and 100% of countries by 2030 will be tracking surgical volume. Our second target is a minimum of 5000 procedures per 100 000 population by 2030. Correlation with several desirable health outcomes suggests that this target is a minimum threshold for delivery of essential surgical and anaesthesia care.[50] This target is not an endpoint target but rather an average minimum threshold. Individual national targets should be made depending on national need. Scale-up is feasible in many LMICs, and these rates of improvement are similar to improvements in LMICs in under-5 mortality and maternal mortality.[51,52]

*Perioperative mortality*

The fourth indicator—perioperative mortality—is crucial for surgical and anaesthesia safety, and has been adopted by the WHO Safe Surgery Saves Lives initiative.[309] The indicator is defined as the number of in-hospital deaths from any cause in patients who have undergone a procedure done in an operating theatre, divided by the total number of procedures, presented as a percentage. Equity stratifiers include residence (urban or rural), sex (female or male), and wealth quintile of the patients. Disaggregates for more advanced monitoring systems include patient age and ASA score; case mix (procedure name), admission diagnosis, and case urgency (planned or emergency).

Perioperative mortality has previously been identified as a credible indicator of surgical safety,[310] with frequently documented and heterogeneous rates reported in the scientific literature (appendix p 150).[311] Perioperative mortality's usefulness as an indicator, particularly one that enables comparisons over time or between jurisdictions, has been restricted by absence of a standardised approach to measurement (appendix p 150),[311] poor understanding of when in relation to surgery it is best measured, and whether risk adjustment is needed.

To address these issues, we looked at perioperative mortality use in four large, mixed surgical datasets from high-income, middle-income, and low-income countries.[312] First, several timeframes for monitoring of perioperative mortality have previously been proposed, including on-table or day-of-surgery (more indicative of anaesthesia safety), 7-day, inpatient, and 30-day (more indicative of overall quality of care) mortality. Although 30-day mortality is often cited as the gold-standard timeframe, in many low-resource settings patients are not followed up after discharge, making 30-day mortality tracking impractical. We noted an acceptable correlation between inpatient mortality and 30-day mortality,[312] making tracking inpatient mortality a feasible alternative to 30-day mortality. Second, both the number of patients who have had a procedure and total number of procedures undertaken (some patients have more than one procedure in a specific admission) have been proposed for use as perioperative mortality denominators. We calculated that the difference in perioperative mortality, if number of procedures was used instead of number of admission episodes, ranged from 10% to 70%,[312] emphasising the importance of a standardised denominator. We chose number of procedures as a denominator because of feasibility (widespread use of operative logbooks documenting procedures undertaken) and because it also provides surgical volume numbers. Third, in terms of risk adjustment, we noted that unadjusted perioperative mortality is satisfactory to start as a baseline, but simple risk adjustment based on patient age, ASA score, and case urgency (emergency or planned) is preferable.[312] Therefore, unadjusted perioperative mortality should be reported for this set of indicators owing to feasibility, but risk adjustment is a future goal for more advanced monitoring systems.

Critics of perioperative mortality use state that some of the sickest patients (and therefore those likely to have the highest risk of mortality) might not have an operation because of their or their physician's fear that the procedure itself will cause death. However, measurement of surgical volume alongside perioperative mortality can help to capture countries not undertaking an adequate volume of procedures (figure 15). Additionally, risk adjustment can help delineate expected rates of death. Finally, the effects of case mix and severity of illness at presentation on perioperative mortality are likely to be less when assessed at a country level (our suggested level of reporting), compared with a facility level. Nonetheless, a higher than expected national perioperative mortality should trigger investigation into whether any particular facility, patient type, or operation has inappropriately higher rates than others.

Our dataset analysis and scientific literature review show that the perioperative mortality can be feasibly collected in countries at all levels of development (appendix p 150).[311,312] Our target is that 80% of countries

by 2020, and 100% of countries by 2030, will be tracking perioperative mortality. In 2020, global data should be reassessed and national targets should be set for 2030.

*Protection against impoverishing expenditure*

The fifth indicator—protection against impoverishing expenditure—is an indicator of financial access to, and financial effect of, seeking essential surgical and anaesthesia care. It is defined as the proportion of households protected against impoverishment from direct OOP payments for surgical and anaesthesia care. Surgical and anaesthesia care includes operative, perioperative, and non-operative management, anaesthesia, and obstetric care for all surgical conditions. Impoverishing expenditure is defined as being pushed into (or further into) poverty by OOP payments.[39] Equity stratifiers include sex (male or female), residence (urban or rural), and wealth quintile of the population. Disaggregates for more advanced monitoring systems include reason for seeking surgical and anaesthesia care (diagnosis given and treatment received), and values for indirect OOP payments.

OOP payments for health care are the predominant form of heath financing in many regions,[43] and an estimated 150 million people face financial catastrophe annually from direct OOP costs of medical care.[44] Although surgery is a cost-effective intervention,[53] it can still be very expensive for patients, as reported in the scientific literature[45–49] and discussed in this Commission. Patients might avoid surgery because they cannot afford it, or they might become financially devastated by seeking or receiving surgical services. The World Bank and WHO have shown commitment to assess rates of impoverishing and catastrophic expenditure due to health care as an indicator of progress towards UHC.[39]

Global health and development organisations have supported prioritisation of financial risk protection within UHC,[39–42] and documentation of impoverishing and catastrophic expenditure from OOP payments for health services is longstanding.[42,56] Our target of 100% protection against impoverishing expenditure from OOP payments for surgical and anaesthesia care by 2030 is necessary to reach the WHO and World Bank target of 100% financial protection from OOP payments for health services by 2030.[39]

*Protection against catastrophic expenditure*

The sixth indicator—protection against catastrophic expenditure—is an indicator of financial access to, and financial effect of, seeking essential surgical and anaesthesia care. The indicator is defined as the proportion of households protected against catastrophic expenditure from direct OOP payments for surgical and anaesthesia care (as defined for the previous indicator). Catastrophic expenditure is defined as direct OOP payments of greater than 40% of household income not including subsistence needs.[314] Equity stratifiers include sex (male or female), residence (urban or rural), and wealth quintile of the population. Disaggregates for more advanced monitoring systems include reason for seeking surgical and anaesthesia care (diagnosis given and treatment received), and values for indirect OOP payments.

The feasibility and target for this indicator is the same as discussed for the protection against impoverishing expenditure indicator.

*Need for collective indicator use and interpretation*

These indicators provide the most information when they are used and interpreted together. Undesirable outcomes provoked by using any one indicator, such as large numbers of inactive clinicians or facilities (if driven by workforce or facility numbers alone), high-volume but low-quality care (if driven by surgical volume alone), or avoidance of complex cases and critically ill patients (if driven by outcome measures alone), can be diminished by collective indicator reporting and assessment. Collective use can also help define problem areas. For example, high perioperative mortality could suggest unsafe surgery and anaesthesia, a selection bias of a population with high preoperative morbidity, or undertaking of high-risk procedures. Analysis of surgical volume alongside perioperative mortality, however, can provide additional information. High perioperative mortality with a mid-level or higher-level surgical volume would be more indicative of poor-quality care (figure 15).

Use of these indicators is a preliminary and minimum step in the monitoring of improvements in surgical and anaesthesia care delivery on the basis of what we deemed was feasible to collect within current information management systems and would meaningfully capture areas of great need (equitable access to timely, affordable, and safe surgical and anaesthesia care). These indicators are necessary to monitor progress towards UHC, and the one health-related SDG: to ensure healthy lives and promote wellbeing for all at all ages. As information systems and care delivery are strengthened, indicators can also progress to focus on other crucial areas including outcomes monitoring, additional aspects of safety, unmet need, and human factors that we did not include in this indicator set owing to absence of immediate feasibility and supporting data. We will reconvene periodically to assess progress made and generate updated recommendations to realise universal access to safe, affordable surgical and anaesthesia care when needed.

*Recommendations for information management National*

- National systems of disease monitoring (whether through civil registration and vital statistics, household surveys, demographic surveillance systems, or verbal autopsies) should capture morbidity and mortality from essential surgical conditions, including injuries and burns, musculoskeletal impairments, digestive diseases, malignancies, wounds, maternal and neonatal disorders, and congenital anomalies.

- More research should be done to identify accurate and feasible methods to establish prevalence of surgical conditions in the population and best methods to ensure and document surgical and anaesthesia safety and outcomes of care.
- Uniformly collected core surgical indicators (including access to timely essential surgery, specialist surgical workforce density, surgical volume, perioperative mortality, protection against impoverishing expenditure, and protection against catastrophic expenditure) should be used by countries to assess preparedness, deliver, and effect of surgical and anaesthesia care.
- To allow tracking of our six core indicators, all facilities and groups delivering surgical and anaesthesia care should collect a minimum surgical dataset and submit that information to their ministries of health or national statistical bodies.
- Core surgical indicators should be analysed at the national level, used to institute necessary changes, and distributed to WHO and the World Bank for global reporting.
- A uniform method for coding surgical conditions and procedures should be agreed upon and used globally to help data analysis and comparison, and to enable reporting of the burden of surgical conditions.
- Facilities and countries should work to strengthen their information systems to allow collection of additional disaggregated information to further inform the six core indicators.

*International*

- All population-based disease monitoring mechanisms, including household surveys, should capture morbidity and mortality from essential surgical conditions, including injuries and burns, musculoskeletal impairments, digestive diseases, malignancies, wounds, maternal and neonatal conditions, and congenital anomalies.
- A uniform method for coding medical and surgical conditions and procedures should be adopted and promoted for use.
- One facility-based survey should be adopted by WHO and used by countries to help comparable assessment of facility availability and readiness to deliver surgical care.
- Our six core surgical indicators should be tracked and reported by global health organisations, such as the World Bank through the World Development Indicators, WHO through the Global Reference List of 100 Core Health Indicators, and entities tracking the SDGs.

For **key findings from the research working group** see appendix p 157

## Research

### The current picture of global surgery research

Through development of this report, we identified substantial deficits in global surgery research focus, practice, and capacity. In this section, we examine the present state of global surgery research and offer recommendations for future research scope and expansion.

Historically, global health research efforts have not focused on diseases with the highest burden or on regions with the greatest clinical need.[188,313,314] Further, disease characteristics and thus research findings from one region of the world might not be generalisable to another region. For example, women in Africa are diagnosed with breast cancer an average of 15 years earlier (by age) than are women in North America and Europe. They have a more advanced stage of cancer at diagnosis and disproportionately higher mortality than those in North America and Europe.[32] This aggressive early onset of breast cancer in Africa compared with Europe suggests different risk factors and disease features. However, full understanding of surgical disease and best treatment practices in LMICs are restricted by an absence of local research on local areas of need.

A shortage of funding, training, and capacity contribute to this research dearth. Funding flows for global health research are small.[315] New research done by our group noted that funding flows for global surgery research are also scant.[236] Additionally, people trained to do research are concentrated in higher-income regions. The UN Educational, Scientific, and Cultural Organization (UNESCO) estimates that only 13% of the world's scientists are located in Africa, Latin America, and the Middle East.[320]

To build on this information and further quantify and characterise the state of global surgery research, we completed a bibliometrics analysis (appendix p 158). Searching the Web of Science, we focused on relative volume of surgical research output between 2009 and 2013 from authors of four country groups: high-income, upper-middle-income, lower-middle-income, and low-income countries.

Overall, a slow increase in surgical research volume was seen with time. Of the 35 countries with the highest volumes, high-income countries had the greatest presence with 264 458 (85%) reports, followed by upper-middle-income countries with 37 838 (12%) reports and lower-middle-income countries with 8371 (3%) reports. No low-income countries were noted within the 35 highest-performing countries. The top high-income country performers were the USA, followed by Germany, the UK, and Japan. The top upper-middle-income countries were China, Turkey, Brazil, and Iran. India, Egypt, and Pakistan had the greatest presence for lower-middle-income countries. Multicountry collaboration on surgical research within income groups was low with the exception of the high-income group. Most collaboration between income groups occurred between high-income countries and the other income groups, accounting for more than half of the low-income group's reports in surgery research.

The highest volume of surgical research is not done in, or by, the countries with greatest clinical need. Rather,

surgical research output correlates with total GDP. A theme heard throughout the Commission process was the need for augmented local research capacity (including funding) and training. This need is not isolated to surgical research[313,315] and is not a newly identified need.[317,318] Building local research capacity for surgery should be prioritised and include so-called South–South collaboration. This might require the skills, resources, and support of high-income country groups.

### Identification of a research agenda

Despite previous attempts to outline low-income and middle-income surgical research agendas,[3,118,319–321] little progress has been made to realise these plans. Global surgery research in the past, led principally by high-income investigators, has focused largely on calling attention to the importance of surgery, the absence of adequate infrastructure, and the cost-effectiveness of surgical intervention. Although high-quality research is still needed to further define these problems, focus is also needed on solutions. To find solutions will require a new era of collaboration, communication, and coordination between local and global partners, ministries of health, academic institutions, funding partners, and global health institutions.

To help unify and maximise global surgery research efforts, we have developed a research agenda based on data and knowledge gaps identified during the Commission process. The first five topics listed next in this section were identified by the Commission as areas with the greatest need for research that could generate the greatest benefit on a worldwide scale. However, research agendas for individual settings should be modified to fit the local context, and site-specific research topics should be identified and driven with collaborations requested by local clinicians, researchers, public health officials, and ministries of health.

#### *Cost and financing*

Little is known about the costs of surgical and anaesthesia care or financing necessities for patients, facilities, and governments. Reliably tracking domestic or international funding flows to surgery in LMICs is not possible at present, so estimation of the financing gap between surgical need and investment is difficult. High-quality, standardised, cost-effectiveness analyses are needed to understand optimum platforms for delivering surgical care. LMIC-specific research investigating how financing of surgical care can be used to improve efficiency and performance and achieve economies of scope and scale with optimum returns on investment is also needed.

#### *Quality and safety*

In addition to improved access to surgical and anaesthesia care, provision of high-quality, safe care should also be a priority. However, what constitutes quality surgical and anaesthesia care is often unclear, and how it is best measured and most feasibly promoted and delivered in low-resource settings is largely unstudied. Much of the research into safety in surgery is based on high-resource settings, and the increasing focus in LMICs has been valuable but mainly limited to pulse oximetry and safety checklists. Additional information is needed to define feasible and effective strategies and best-practice protocols for surgical and anaesthesia care delivery in LMICs.

#### *Care delivery innovations*

Research and development for areas of historical global health priority have led to new drugs, vaccines, and diagnostics. Similar high-quality, low-cost, setting-appropriate innovative technologies and strategies for the diagnosis and treatment of surgical conditions are needed. Research on innovative methods for reliable supply chains for surgical equipment, supplies, and drugs; safe waste disposal; and diagnostics, including pathology, laboratory, and imaging capabilities, should be included. Such innovations can improve care delivery in countries of all income levels.

#### *Burden*

Actual data pertaining to burden of surgical conditions is scarce. Without prevalence data, areas of greatest need are unknown, compromising abilities to plan services, advocate for and allocate resources, institute preventive strategies, or assess effect. Research on surgical condition prevalence, collected widely and via methods that allow for comparison, is needed. This work could lead to an indicator tracking unmet burden of surgical conditions.

#### *Determinants and barriers*

Causes of and risk factors for surgical disease vary by setting and often differ in LMICs compared with those more heavily researched in high-income countries. The ability to tailor appropriate strategies to improve access, delivery, and prevention is compromised by poor understanding of disease risk factors and barriers to care delivery. Additional information about determinants (social, occupational, environmental, genetic, geographic, and demographic) of surgical disease and barriers to care is needed through basic science, social science and clinical research.

#### *Impact*

Knowledge of the disease effect at individual, household, system, population, and economic levels is important to guide advocacy, policy change, and resource allocation. Little is known about the social, physical, financial, or economic effect of many surgical conditions. Data about ways in which surgical services can best strengthen various components of the health system (eg, how laparoscopy in Mongolia has improved surgeon satisfaction and increased the population's confidence in locally provided health

care)[49] are missing. Information about the effect of surgical conditions and delivery of surgical services is necessary to direct prevention, treatment, capacity building, policy, and funding strategies.

*Prevention*

Preventive strategies can reduce the incidence, development, and severity of surgical disease. For example, improved road traffic safety can prevent road traffic injuries, human papillomavirus screening can prevent development of cervical cancer, and cleft lip and palate repair can improve nutrition and speech. Research into effective prevention strategies is needed to decrease the development of and morbidity from surgical conditions.

*Partnership*

Partnerships, whether between care delivery groups, academic institutions, funding organisations, or the private and public sectors, can be valuable to improve delivery of affordable surgical and anaesthesia care. However, little data exist to describe best practices for maximising benefit of these partnerships for surgery. Research into partnership roles, particularly the present landscape, efficiencies, quality, and best practices, are needed to lead future policy recommendations and maximise collaborative benefit.

*Training and education*

Insufficient human resources restrict delivery of equitable surgical and anaesthesia care. Research is needed to identify innovative and effective practices for training, education, monitoring, expansion, and retention of all members of the surgical workforce in LMICs. Information about building surgical leadership and management skills is also needed.

*Policy*

Social science and political scholarships should be applied to delivery of surgical services to develop methods for improved political prioritisation of surgery. More information is needed about best policy practices to improve access to surgical and anaesthesia care, and to create effective governance to generate and achieve policy goals.

*Information management*

The availability of information about surgery and anaesthesia on a global level is scarce. More research is needed into what data can accurately represent the present picture of the burden of surgical conditions and delivery of surgical and anaesthesia care and how those data are feasibly collected and presented.

***Panel 9:* Future research: considerations for implementers, funders, editors, and ethics committees**

**Appropriateness**

Does the project promote appropriate interventions or applications for the region? If it merely assesses the uptake of a non-supportable technique from a different setting, then this might be very much in doubt. If it uses techniques that can easily be replicated in the country for which they are being proposed, it might be appropriate.

**Ownership**

Is evidence of local initiation and ownership of the project available? The most desirable ventures are those initiated by and led by local teams.

**Authorship**

Are authors from the country where the work was (or is proposed) to be done, or are they from other countries? Projects should be done by or, at minimum, involve local researchers.

**Local capacity building**

Does the research build local research capacity? If all discussion and analysis is done outside of the country, then the answer might be no. Evidence of improved capacity for further research after project completion should be available.

**Consent**

Has consent been appropriately obtained (if it is culturally appropriate in the particular situation)? Potential research participants might find it difficult to say no to participation in any surgical study owing to possible power dynamics and fear that refusal could lead to denial of care. Participants should be given a clear opportunity to discuss the study, and should realise their treatment is not dependent on study participation.

**Treating identified conditions**

What happens when pathological abnormalities are identified? Research studies might identify disease that the research team is unable to treat both in research participants and their accompanying family. What should the research team do about this? If a disorder is diagnosed during the course of a research project, a plan to facilitate appropriate treatment should be in place.

**Quality**

Is the project good science? If not, then it should be rejected, with clear reasons and suggestions for how to improve the next submission.

## Considerations for funders, editors, and ethics committees or institutional review boards

Although research and collaborative endeavours have potential to greatly improve care delivery, the risk of unintended harm and negative outcomes is substantial. To maximise benefit and minimise harm, we assembled an advisory team to generate a list of considerations for funders, editors, and institutional review boards when assessing global surgical research projects. The team reviewed PubMed for all published reports originating from surgical units in COSECSA countries from 2009 to 2014. Using Delphi methods, the advisor team then spoke to existing academic and clinical leaders in all branches of surgery in the countries represented by COSECSA, asking what they thought should be priorities for future research, and what funders, editors, and ethical committees should consider. Panel 9 presents the results of these discussions, presented in the form of questions that implementers, funders, editors, and ethics committees of global surgery research could consider. They should be adapted as necessary to fit the cultural context of the environment in which they are used.

### Recommendations for research

*National and international*

- An increase in research capacity, training, funding and output in LMICs should be a priority on both local and global levels.
- Local research should be facilitated with international funding and capacity-building partnerships, and driven by local priorities.
- In addition to further defining the problem, global surgery research focus should also extend to identification of solutions, particularly in the areas of cost and financing, quality, safety, care delivery innovations, and disease determinants.
- Funders, editors, and ethical committees should consider a list of core questions, such as those identified by the Commission, when reviewing global surgery research projects.

## National surgical plan

The development of resilient surgical systems will need commitment and engagement from various stakeholders at the national and international levels, and from public, private, and charitable sectors. A national strategic plan that specifically addresses surgery is essential for the proper planning of care delivery, education, and research. This plan should be country and context specific, developed and owned by all stakeholders, and rest within a broader strategy of improvement of national health systems.

Here we present a framework for a national surgical plan that addresses five major domains of surgical systems development: infrastructure, workforce, service delivery, information management, and financing. Each domain consists of several components, selected to be representative but not exhaustive elements for systems development within that domain. Accompanying these components are the Commission's relevant recommendations and a proposed system of assessment and evaluation of progress.

Not all aspects of these assessments will be directly relevant to all contexts, and not all aspects of the assessments suggested in this framework will be readily collectible at the outset. Nonetheless, improvement in access to care starts with an acknowledgment of the unknown followed by implementation of a plan to fill those gaps in knowledge.

Surgical systems, despite their differences, share striking similarities across context depending on resource level. The burden of disease varies, however, as do the capabilities of the present system. This suggested framework, then, is meant to serve as a flexible template upon which to build a context-appropriate, comprehensive plan with time-bound targets (table 7).

## Conclusions

Surgical and anaesthesia care must become an integral component of health care and health systems in LMICs to realise our vision of universal access to safe, affordable surgical and anaesthesia care when needed. At present, gross global inequity exists in the burden of surgical conditions and in access to surgical and anaesthesia care between high-income countries and LMICs. Surgery has long been overlooked as a health need for the world's poorest people. As a result, untreated surgical conditions have exerted substantial but largely unrecognised negative effects on human health, welfare, and economic development. In this Report, we have shown that the magnitude of human suffering from surgical conditions is large: each year up to 140 million people need surgical procedures to save their lives or to prevent long-term disability, but do not get them. More than 30 million more people are impoverished in the process of seeking surgical and anaesthesia care because of OOP health costs and greater than 70% of the world's population does not have access to timely, safe, and affordable surgical and anaesthesia care should they need it. The economic and development effects are also substantial: up to 2% of potential annual economic growth is lost in LMICs as a result of surgical conditions. Although the present situation in many LMICs is deeply problematic, this Commission has shown that many opportunities exist for substantial, tangible improvements to occur in the next 15 years and beyond.

2015 is a pivotal year for global health, and can be one for global surgery too. New opportunities exist to address health-care inequity and to reset the global health agenda to meet present and new health challenges. These include global commitments to achievement of UHC, greater strategic investments in health, and the launch of a new set of SDGs, which aim to end poverty, promote sustainable economic growth, and ensure health for all at all ages by tackling infectious diseases, non-communicable diseases, and injuries. The full realisation of these promises will only be possible by strengthening of health services and health systems, including strengthening of the delivery of safe, affordable, and timely surgical care.

In 2015, we urge local, national, and global health stakeholders to commit to the provision of better global surgical and anaesthesia care. Not as an additional or competing health and development goal, but as a crucial component of many existing ones. Better global surgical and anaesthesia care will only be realised through increased investment in human and physical resources for surgery and anaesthesia, accompanied by a focus on safety, quality, and efficiency. Our cost estimates for scaling up surgical and anaesthesia care in LMICs are low compared with the economic and human welfare returns imparted through widespread provision of basic surgical services. Early and urgent domestic and external investment in surgical and anaesthesia care is needed to realise these returns. Prompt action is especially important in view of the rising burden of cancer and injuries in LMICs, which need surgical and anaesthesia care in most cases and

| | Recommendations | Assessment methods |
|---|---|---|
| **Infrastructure** | | |
| Surgical facilities; facility readiness; blood supply; access and referral systems | • Track number and distribution of surgical facilities<br>• Negotiate centralised framework purchase agreements with decentralised ordering<br>• Equip first-level surgical facilities to be able to do laparotomy, caesarean delivery, and treatment of open fracture (the Bellwether Procedures)<br>• Develop national blood plan<br>• Reduce barriers to access through enhanced connectivity across entire care delivery chain from community to tertiary care<br>• Establish referral systems with community integration, transfer criteria, referral logistics, and protection for first responders and helpful members of the public | • Proportion of population with 2 h access to first-level facility<br>• WHO Hospital Assessment Tool (eg, assessment of structure, electricity, water, oxygen, surgical equipment and supplies, computers and internet)<br>• Proportion of hospitals fulfilling safe surgery criteria<br>• Blood bank distribution, donation rate |
| **Workforce** | | |
| Surgical, anaesthetic, and obstetric providers; allied health providers (nursing, operational managers, biomedical engineers, and radiology, pathology, and laboratory technician officers) | • Establish training and education strategy based on population and needs of country<br>• Require rural component of surgical and anaesthetic training programmes<br>• Develop a context-appropriate licensing and credentialling requirement for all surgical workforce<br>• Training and education strategy of ancillary staff based on population and needs of country<br>• Invest in professional health-care manager training<br>• Establish biomedical equipment training programme | • Density and distribution of specialist surgical, anaesthetic, and obstetric providers<br>• Number of surgical, anaesthetic, and obstetric graduates and retirees<br>• Proportion of surgical workforce training programmes accredited<br>• Presence of task sharing or nursing accredited programmes and number of providers<br>• Presence of attraction and retention strategies<br>• Density and distribution of nurses, and ancillary staff including operational managers, biomedical engineers, and radiology, pathology, and laboratory technicians |
| **Service delivery** | | |
| Surgical volume; system coordination; quality and safety | • All first-level hospitals should provide laparotomy, caesarean delivery, and open-fracture treatment (Bellwether Procedures)<br>• Integrate public and private NGO providers into common national delivery framework; promote demand-driven partnerships with NGOs to build surgical capacity<br>• Prioritise health-care management training<br>• Prioritise quality improvement processes and outcomes monitoring<br>• Promote telemedicine to build system-wide connectivity<br>• Promote system-wide connectivity for telemedicine applications, clinical support, and education | • Proportion of surgical facilities offering the Bellwether Procedures<br>• Number of surgical procedures done per year<br>• Surgical and anaesthetic related morbidity and mortality (perioperative)<br>• Availability of system-wide communication |
| **Financing** | | |
| Health financing and accounting; budget allocation | • Cover basic surgical packages within universal health coverage<br>• Risk pool with a single pool; minimise user fees at the point of care<br>• Track financial flows for surgery through national health accounts<br>• Use value-based purchasing with risk-pooled funds | • Surgical expenditure as a proportion of gross domestic product<br>• Surgical expenditure as a proportion of total national health-care budget<br>• Out-of-pocket expenditures on surgery<br>• Catastrophic and impoverishing expenditures on surgery |
| **Information management** | | |
| Information systems; research agenda | • Develop robust information systems to monitor clinical processes, cost, outcomes, and identify deficits<br>• Identify, regulate, and fund surgical research priorities of local relevance | • Presence of data systems that promote monitoring and accountability related to surgical and anaesthesia care<br>• Proportion of hospital facilities with high-speed internet connections |

These components addressing surgical care should be incorporated within a broader strategy of improvement of national health systems. NGO=non-governmental organisation.

*Table 7:* **National surgical plan components and framework**

when untreated are projected to profoundly affect national productivity and welfare.

Alongside scaling up of surgical and anaesthesia care, a further major conclusion is the pressing need for financial risk protection against the costs of surgery for individuals in LMICs. Financial protection is needed to prevent medical impoverishment and to improve access to surgical and anaesthesia care, especially for people with a low income. Essential surgical procedures, packages, and platforms aimed at saving lives and preventing major disability should be included within country-level and international UHC policies, which the Commission believes should be pro-poor and financed through public risk pooling.

Finally, research, monitoring, and assessment play a crucial part in the future of global surgical and anaesthesia care. Inattention to the suffering imposed by surgical conditions, a paucity of scientific rigor around implementation science, and a complete absence of globally accepted surgical metrics are factors that have all contributed to the neglect of surgical and anaesthesia care within global health during the past two decades. A commitment to better understand the problems and solutions should be a priority goal for those dedicated to improvement of surgical and anaesthesia care worldwide.

During the course of this Commission, thousands of contributors from more than 110 different countries across six continents came together in support of global surgery. All contributors have emphasised the global need for better surgical and anaesthesia care, as experienced from within their own communities and the

symbiotic association between surgical and anaesthesia care and health systems. Although efforts to improve surgery and anaesthesia in LMICs should be grounded in the reality of those on the frontline and driven by local need, the causes of inadequate and inequitable surgical and anaesthesia care are clearly both a worldwide concern and a worldwide responsibility. Realisation of the vision of this Commission will require further harnessing of this powerful global network. Coordinated and sustained efforts that are solution-orientated are needed at all levels, to generate political priority, mobilise resources, and assure action and meaningful improvements. Using *The Lancet* as an independent forum and mechanism, this Commission will continue to measure progress in global surgical and anaesthesia care and demand accountability at a national and international level for surgical capacity and outcomes in LMICs. We will do so supported by a growing global network and movement committed to better surgical and anaesthesia care for all.

#### Contributors

All commissioners and authors contributed to the key messages, conclusions, recommendations, writing, and editing of the Commission. Substantial contributions to the research and data gathering were done by a core research team listed in the acknowledgments section of the appendix. Additional research support, counsel, and advice were supplied by several important individuals and organisations also listed in the appendix (p 176). All research was done under the leadership of the Commission cochairs (JGM, AJML, and LH) and the Working Group Leads (NR, EAA, GLY, and RLG; appendix p 176) with assistance from NPR, JNR, AD, and SLMG respectively.

#### Declaration of interests

LH reports grants from the Swedish Society for Medical Research and the Swedish Society of Medicine. JD is an editor at the *Lancet* journals. MGS reports personal fees from Ethicon. AG, TGW, and IHW serve on the board of Lifebox. SB is in the process of submitting the required information to the technology transfer office at the University of California, San Diego with regard to patenting a method for estimating the need for surgical care in a population. ER was the founder and President of Cinterandes Foundation. All other authors declare no competing interests.

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