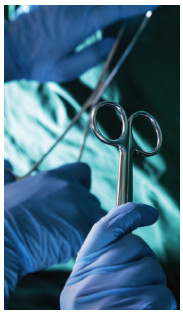

Chapter 2

Global Burden of Surgical Conditions

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INTRODUCTION

Approximately 2 billion people lack access to emergency and essential surgical care (Funk and others 2010). Most of the need is in rural and marginalized populations living in low- and-middle-income countries (LMICs), where the poorest one-third of the world's population receives only 3.5 percent of all surgical procedures (Weiser and others 2008). The lack of surgical care takes a serious human and economic toll and can lead to acute, life-threatening complications. In other instances, poor-quality care results in chronic disabilities that make productive employment impossible and impose a burden on family members and society.

The failure to appreciate the role of surgery in addressing important public health problems is the main cause of disparities in surgical care worldwide. Yet, surgically treatable conditions—such as obstructed labor (Alkire and others 2012; Ndour and others 2013); injuries (Abdur-Rahman, van As, and Rode 2012; Mock and others 2012); intra-abdominal emergencies (Stewart and others 2014); correctable congenital anomalies, such as clubfoot and cleft lip or palate (Mossey and Modell 2012; Wu, Poenaru, and Poley 2013); symptomatic hernias (Beard and others 2013); cataracts (Rao, Khanna, and Payal 2011); osteomyelitis (Bickler and Rode 2002; Stanley and others 2010); and otitis media (Monasta and others 2012)—contribute to premature deaths or ill health of populations.

In this chapter, we explore surgery's multifaceted contribution to global public health. We begin by providing an overview of the public health dimensions of surgical care in LMICs and examine the current challenges of making a comprehensive assessment of the global burden of surgical diseases. Next, we estimate the public health impact in LMICs if basic and selected subspecialty surgical care could be scaled up to meet standards that currently exist in high-income countries (HICs). Finally, we attempt to define where surgical care fits among other global health priorities and discuss areas toward which future research should be focused. Our analysis uses the 21 epidemiology regions from the Global Burden of Diseases, Injuries, and Risk Factors Study 2010.

ROLE OF SURGERY IN GLOBAL HEALTH

Public Health Dimensions

In the second edition of *Disease Control Priorities in Developing Countries*, Debas, McCord, and Thind (2006) describe four types of surgical interventions that have a public health dimension:

- The provision of competent, initial surgical care to injury victims to reduce preventable deaths, as well as to decrease the number of survivable injuries that result in disability

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- The handling of obstetrical complications, such as obstructed labor and hemorrhage
- The timely and competent surgical management of a variety of abdominal and extra-abdominal emergency and life-threatening conditions
- The elective care of simple surgical conditions, such as hernia, clubfoot, cataract, hydroceles, and otitis media

Based on expert opinion, Debas, McCord, and Thind (2006) estimate that 11 percent of the global burden of disease measured in disability-adjusted life years (DALYs) could be treated with surgery. Their estimates range from 7 percent for Sub-Saharan Africa to as high as 15 percent for Europe. Although based on incomplete information and a limited number of surgical procedures, the 11 percent estimate is one of the most widely quoted figures in global surgery.

Why surgically treatable conditions are not more widely appreciated as a critical public health problem is an important question. Although the answer is complex, it is in part related to the misconception that surgical care is too costly. Surgical care can, in fact, be remarkably cost-effective, even in comparison with nonsurgical interventions that are commonly implemented as public health measures. For example, the cost of emergency obstetric care at a rural hospital in Bangladesh was estimated to be US$11 per DALY averted (McCord and Chowdhury 2003). The same measurement for all surgical care services provided by a hospital in Sierra Leone was just US$33 per DALY averted (Gosselin, Thind, and Bellardinelli 2006). These costs compare favorably with many other primary interventions, such as vitamin A distribution (US$9 per DALY averted), acute lower respiratory infection detection and home treatment (US$20 per DALY averted), or measles immunization (US$30 per DALY averted) (Grimes and others 2014; Ozgediz and Riviello 2008).

Importance of Preventive and Curative Services

During the past several decades, public health professionals have come to understand that successful health care depends on both prevention and curative intervention. Because prevention is rarely 100 percent effective, clinical services will always be needed. This principle applies to a broad spectrum of health care problems in LMICs. Examples include malaria control programs, through which bed nets can reduce but not eliminate the need to treat symptomatic cases, as well as maternal health programs, in which cesarean section must be an available treatment option for cases of obstructed labor. With respect to the latter, approximately 10 percent to 15 percent of pregnancies will require emergency obstetrical care (Gibbons and others 2010). The experience with controlling HIV infection in LMICs is particularly germane because programs are most successful when screening and prevention strategies are combined with treatment. Striking a balance between prevention and clinical programs has proved to be especially challenging in LMICs, where there is fierce competition for limited resources. Nevertheless, clinical services must be available if the health needs of a population are to be appropriately met.

CHALLENGES ESTIMATING A GLOBAL BURDEN OF SURGICAL DISEASE

The Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (known as GBD 2010) (Murray, Vos, and others 2012) reinforces use of the DALY as the preferred metric for determining the relative contribution of disease categories to the overall burden of disease. The DALY is a summary measure of population health that sums up fatal burden and nonfatal burden into a single index: years of life lost (YLLs) and years lived with disability (YLDs). Because the GBD framework is increasingly used as a factor to inform resource allocation in LMICs, it is extremely important that the impact of surgical care be estimated using the DALY metric, if possible. Nevertheless, in the process of trying to estimate a global burden of surgical disease, we encountered several challenges when analyzing surgical care using this metric.

Challenge 1: Defining Surgical Care

Confusion persists about what constitutes surgical care and the role surgery should have in settings of limited resources. Surgery is often defined as it relates to specific procedures, but this definition fails to recognize the larger role that surgical care has in clinical practice. Our preferred surgical definitions are shown in box 2.1. In addition to the technical execution of an operation, surgical care encompasses the preoperative assessment of patients, including deciding whether to operate; intraoperative anesthetic management; and postoperative care—all of which are major determinants of surgical outcomes.

More important and frequently ignored is that surgeons often provide nonoperative care to their patients. Examples include the airway management of injured patients; the use of traction in extremity fractures; the care of most head injuries; and the nonoperative management of the majority of blunt abdominal injuries,

Box 2.1

Surgical Terminology

Surgically treatable condition: Any condition in which surgical care can potentially improve the outcome

Surgical care: Operative and nonoperative interventions directed at reducing the disability or premature death associated with a surgically treatable condition; surgical care includes the preoperative assessment of patients, intraoperative care including anesthesia, and postoperative care

Surgical procedure: The suturing, incision, excision, or manipulation of tissue; or other invasive procedure that usually requires local, regional, or general anesthesia

Surgical sequelae: Abnormalities that result from a surgically treatable condition in the absence of surgical care or sometimes as an adverse event

Surgical disability: Physical deficit associated with a surgical sequela.

Source: Adapted from Bickler and others 2010.

for example, a spleen injury in a child. Although surgical care has an important role in the diagnosis and treatment of many diseases, it can also have a role in prevention, as in the use of circumcision to prevent HIV infection.

Challenge 2: Distinguishing between Surgical and Nonsurgical Conditions in the GBD 2010 Study

Efforts to estimate a global burden of surgical disease have been predicated on the idea that GBD causes must be classified as either surgical or nonsurgical. To test this assertion, and to gain better insight into the role of surgery in a high-functioning health system, we queried the U. S. National Inpatient Sample (NIS)[1] to determine operative rates for each of the GBD 2010 disease and injury categories (Rose and others 2014). This database is the largest all-payer inpatient care database in the United States, containing data on more than 7 million hospital stays each year. This database cannot be expected to represent what occurs globally, but it can provide insight into operative rates in a well-resourced health system.

We compiled all International Classification of Diseases, Version 9 (ICD-9) codes from the NIS from 2010 and grouped the NIS primary diagnosis codes into GBD 2010 disease categories. The ICD-9 codes used in the GBD 2010 were extracted from table 4 of the Supplement material of the GBD 10 (annex 2A to this chapter; Lozano and others 2012). We determined the fraction of admitted patients in each GBD cause category who underwent an operation. *Operation* was defined as a surgical procedure performed in an operating room on inpatients. This definition and corresponding ICD-9 procedure codes are standardized and publicly available through the Agency for Healthcare Research and Quality (AHRQ 2008). The details of our analysis, along with the AHRQ list of surgical procedures, can be found in annexes 2B and 2C.

In 2010, 10 million inpatient operations were performed in the United States and were associated with 28.6 percent of all admissions. Operations were performed in every GBD 2010 cause subcategory (frequency prevalence ranged from 0.2 percent to 84.0 percent). The highest frequencies were in the subcategories of musculoskeletal (84.0 percent); neoplasm (61.4 percent); and diabetes, urological, blood, and endocrine disease (33.3 percent) (figure 2.1). The GBD 2010 framework captured 80.1 percent of inpatient operations; 19.9 percent of operations were performed on patients with a primary diagnosis not included in the GBD 2010 framework. The two most common missed ICD-9 codes were single live birth, both with and without cesarean section. With childbirth being a precarious process in many settings, it illustrates that this important process is not captured in the GBD framework.

Surgical care thus cuts across the entire spectrum of GBD 2010 cause categories, calling into question dichotomous traditional classifications of *surgical* versus *nonsurgical* disease. There was no disease subcategory that required an operation 100 percent of the time, nor was there any that never required an operation. The neoplasm subcategory is an excellent example. In our study, 61.4 percent of patients admitted for treatment of a neoplasm diagnosis underwent a surgical procedure. Certainly there is disagreement about whether to classify all patients with a neoplasm as surgical patients. Yet surgical care plays an important role in the diagnosis (biopsy), treatment (resection), and supportive care (chronic intravenous access) of patients with tumors. Although operative rates vary by country, and our study could not evaluate specific indications or outcomes of procedures, the findings illustrate the integrative nature of surgical care within a health system.

Figure 2.1 Chance of a Patient Admitted to the Hospital in a Well-Resourced Health System Requiring a Surgical Procedure in the Operating Room

Source: Rose and others 2014, based on the National (Nationwide) Inpatient Sample (NIS), 2010, Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality, Rockville, MD, http://www.hcup-us.ahrq.gov/db/nation/nis/nisdbdocumentation.jsp.

Challenge 3: Assigning DALYs Averted Values to Large Numbers of Surgical Procedures

Modern surgical care has an impressive armamentarium of surgical procedures—everything from the drainage of a simple abscess to the repair of complex congenital heart anomalies. The AHRQ list used in the database analysis includes ICD-9 procedure codes for more than 2,500 major operations (annex 2C). To accurately calculate DALYs averted by a given surgical procedure, one must know the disability weight associated with a

particular condition, the effectiveness of the operation in reducing incidence and mortality, and its ability to affect duration or severity of the condition. The effectiveness of an operation varies by the type of operation; resources available to conduct the operation; operative skills of the surgeon; capability and resources of anesthesia personnel; and patient factors, such as nutritional status and other comorbidities. The large number of surgical procedures and the variability in operative outcomes make a comprehensive calculation difficult, if not impossible.

Strategy for Assessing the Public Health Impact of Surgical Care in LICs and MICs

Given the complexities and inherent challenges of estimating an accurate global burden of surgical disease, we adopted an alternative strategy for assessing the public health impact of surgical care in LMICs. Instead of trying to make a comprehensive assessment of all surgical care, we focused our efforts on estimating the public health impact of scaling up basic surgical care deliverable at first-level hospitals and selected subspecialty care. Our goal was to capture the most important surgical procedures that have the highest impact on improving public health.

BURDEN AVERTED BY SCALING UP BASIC SURGICAL CARE[2]

Rationale

During the past decade, interest in building surgical capacity at first-level hospitals in LMICs has increased. The rationale for this strategy is that a large percentage of the world's population receives emergency care at first-level facilities. Moreover, many surgical conditions—particularly obstetric emergencies, intra-abdominal catastrophes, and life-threatening injuries—require that appropriate care be immediately available if lives are to be saved.

In response to this challenge, the World Health Organization (WHO) launched two complementary initiatives: the Emergency and Essential Surgical Care (EESC) program in 2004 and the Global Initiative for Emergency and Essential Surgical Care (GIEESC) in 2005 (Abdullah, Troedsson, and Cherian 2011; Bickler and Spiegel 2010; Spiegel and others 2013). The goal of the EESC project was the development and implementation of training materials to improve care for surgical conditions at first-level facilities in LMICs; the objective of the GIEESC project was to stimulate collaboration among governments, organizations, agencies, and institutions involved in reducing death and disability from surgically treatable conditions. The 2012 Copenhagen Consensus reaffirmed the need to strengthen surgical capacity in the developing world, emphasizing that very low-cost investments could be highly effective (Copenhagen Consensus Center 2012).

As funders and national policy makers consider the expansion of health systems in LMICs, it is imperative that they understand the potential impact that scaling up basic surgical care deliverable at first-level hospitals could have on population health.

Methodology

Our analysis assumes a basic surgical package with various therapeutic interventions that could be provided at first-level hospitals. These conditions were selected based on recommendations and guidelines in the literature (Mock and others 2010; WHO 2003); consultation with experts in global surgery; practicality in quantifying health outcomes, for example, the existence of clear health outcomes corresponding to specific surgical procedures; and a corresponding cause in GBD 2010. We examined the following:

- *Four digestive diseases:* Appendicitis, paralytic ileus[3] and intestinal obstruction, inguinal and femoral hernia, and gallbladder and bile duct disease
- *Four maternal-neonatal conditions:* Maternal hemorrhage, obstructed labor, abortion, and neonatal encephalopathy
- *Injuries that could be treated with basic interventions:* Resuscitation, surgical airway, peripheral venous access, suturing, laceration and wound management, chest tube or needle decompression, fracture reduction, escharotomy, fasciotomy, skin grafting, trauma-related amputation, and trauma-related laparotomy

To investigate which surgical procedures would be required to treat this group of surgical conditions, we searched Surgical Care for the District Hospital (WHO 2003) for procedures that corresponded to the GBD causes. Our review showed that almost 50 surgical procedures are required to treat these GBD causes, illustrating that a broad spectrum of procedures are required to treat even a limited list of surgical conditions (annex 2D).

Our burden estimates were based on data from the GBD 2010 (Murray, Vos, and others 2012). Parameters included population, standard life expectancy, cause-specific mortality, incidence, prevalence, and disability weights (Lozano and others 2012; Salomon and others 2012; Vos and others 2012). The parameters were

specific by cause, age, gender, region, and year. The GBD 2010 groups countries into 21 epidemiological regions (17 of which contain LMICs) and seven superregions (six of which contain LMICs) (table 2.1). Our analysis was conducted at the superregion level by aggregating regional-level parameters.

Our approach recognized that some conditions, such as maternal hemorrhage and neonatal encephalopathy, are not fully amenable to surgical care and required adjustments to limit the effect of surgery. Other GBD causes (such as drowning, poisoning, self-harm, venomous animal contact, and injuries not classified elsewhere) were assumed to be not amenable to surgery. When questions on the proportions of conditions that could be managed by surgical care arose, we referred to the literature and adjusted the avertable burden accordingly. Additional details on the adjustments to account for the burden not amenable to surgical care can be found in annex 2E.

The overall concept of the approach was to split the reported DALYs of surgical conditions in 2010 into surgically avertable burden and surgically nonavertable burden. The avertable burden was calculated as follows:

$$\text{Avertable burden} = DALY^{Current} - DALYcf, \quad (2.1)$$

in which $DALY^{Current}$ denotes the DALYs reported in GBD 2010, and *DALYcf* the estimated DALYs if the delivery of surgical care had existed in a counterfactual state in which the entire population had access to appropriate and safe surgical care appropriate for delivery at the first-level hospital. The counterfactual level equates to the outcome that is achievable across all segments of the health care system in HICs.

To determine the *DALYcf* quantity, we estimated *YLLcf* and *YLDcf* for the counterfactual state in separate steps. Such separation in estimating fatal and nonfatal burden is consistent with the approach used in generating the GBD 2010 estimates.

We first estimated the number of deaths for the counterfactual state in LMIC superregions with the following equation:

$$DEATHcf_{age,\ gender}^{superregion} = Incidence_{age,\ gender}^{superregion} \times CFRcf_{age,\ gender}, \quad (2.2)$$

in which $DEATHcf_{age,\ gender}^{superregion}$ is the age- and gender-specific number of deaths for the counterfactual state in each superregion, $Incidence_{age,\ gender}^{superregion}$ the age- and gender-specific number of incident cases from GBD 2010 in each superregion, and $CFRcf_{age,\ gender}$ the age- and gender-specific case fatality rates for the counterfactual state.

$CFRcf_{age,gender}$ values would ideally be informed by complete data on coverage, access, quality, and effectiveness of surgical care in each region. Although such data exist for some LMICs and a subset of causes in our analysis, it is very sparse (Choo and others 2010; Galukande and others 2010; Kushner and others 2010).

We therefore assigned the lowest fatality rates among the 21 epidemiological regions for each age and gender to be representative of $CFRcf_{age,gender}$. In addition to being consistent across conditions, we believe this value best reflects the situation of the counterfactual state in which diagnosis is reasonably prompt, treatment is available, and there is access to appropriate and safe surgical care. Not surprisingly, the majority of lowest CFRs were from one of the HICs: high-income Asia Pacific, Western Europe, Australasia, and high-income North America.

After calculating $DEATHcf_{age,\ gender}^{superregion}$, we multiplied this quantity by the age-specific standard life expectancy used in GBD 2010 to estimate the fatal burden for the

Table 2.1 GBD 2010 Epidemiological Regions and Groupings into LMIC Superregions

GBD 2010 epidemiological regions		LMIC superregions
High-income countries	1. High-income Asia Pacific	
	2. Western Europe	
	3. Australasia	
	4. High-income North America	
Low- and middle-income countries	5. Central Europe	Eastern Europe and Central Asia
	6. Eastern Europe	
	7. Central Asia	
	8. Southern Sub-Saharan Africa	Sub-Saharan Africa
	9. Eastern Sub-Saharan Africa	
	10. Central Sub-Saharan Africa	
	11. Western Sub-Saharan Africa	
	12. North Africa and Middle East	Middle East and North Africa
	13. South Asia	South Asia
	14. Southeast Asia	
	15. East Asia	East Asia and Pacific
	16. Oceania	
	17. Southern Latin America	Latin America and the Caribbean
	18. Tropical Latin America	
	19. Central Latin America	
	20. Andean Latin America	
	21. Caribbean	

counterfactual state (Lozano and others 2012; Murray, Ezzati, and others 2012) using the following formula:

$$YLLcf_{age,\,gender}^{superregion} = Deathcf_{age,\,gender}^{superregion} \times Standard\ life\ expectancy_{age,\,gender}. \quad (2.3)$$

The next step was to estimate the nonfatal burden (*YLDcf*) for the counterfactual state. Although scaling up surgical coverage would reduce fatal burden (YLL), the averted deaths would still contribute to the nonfatal burden for a shorter—or sometimes longer—duration, as estimated by YLDs. YLDs in GBD 2010 were calculated by multiplying the prevalent cases by disability weights that are unique to each health state. However, we did not know the direct impact of reduced CFRs on prevalence. For diseases that had a short duration, defined as less than one year, we calculated the YLDs for the counterfactual state as follows:

$$YLDcf_{age,\,gender}^{superregion} = \left(Incidence_{age,\,gender}^{superregion} - Deathcf_{age,\,gender}^{superregion}\right) \times Duration \times DW, \quad (2.4)$$

in which $YLDcf_{age,\,gender}^{superregion}$ is the nonfatal burden in the counterfactual state, *Duration* is the duration of disease calculated by dividing the prevalence by incidence, and *DW* the disability weight attached to each condition from the GBD 2010 study. For injury conditions with long-term sequelae that exceeded a year, we used a slightly different equation:

$$YLDcf_{age,\,gender}^{superregion} = Incidence_{age,\,gender}^{superregion} \times YLD\ per\ incident\ case_{age,\,gender}^{lowest\ from\ all\ regions}. \quad (2.5)$$

The final step was to calculate the avertable burden, which was accomplished by summing the *YLDcf* and *YLLcf* for each region and then subtracting the total from the total DALYs estimate from GBD 2010, and aggregating the results to the superregion level. Additional details on how burden calculations were performed can be found in the four manuscripts included in annex 2F.

Results were expressed as the number of deaths and burden (DALYs) that would be averted per year by scaling up care for a group of surgically treatable conditions in LMICs. This care would be appropriate for first-level hospitals and would include treatment for four digestive diseases, four maternal-fetal conditions, and injuries that could be treated with basic interventions. Our estimates are based on the assumption that surgical care could be scaled up to match the accessibility and quality of care provided in HICs—the counterfactual rate—either at first-level hospitals or at higher levels of care.

Because surgical care can never completely prevent or reverse disability, we have also included an estimate of the nonavertable burden. The nonavertable burden refers to the fraction of the burden that is currently not preventable or reversible with surgical care. Perhaps the best examples of nonavertable burden occur in injured patients for whom death and disability often occur even when the best possible surgical care is available. Two examples are an amputation for a severely mangled extremity and a fatality from a severe head injury before the patient arrives at the hospital. The outcomes are unavoidable and thus nonavertable with surgical care.

Some may question the value of including data on the nonavertable burden given that we have focused our efforts on trying to define the role of surgery in reducing death and disability. Nevertheless, we have included these data for two important reasons. First, nonavertable does not necessarily imply a problem that cannot be addressed: nonavertable burden can be reduced through nonsurgical means, for example, injury prevention, improved delivery of care, or innovation. Second, without a complete accounting of total burden—the avertable and nonavertable burden—it is impossible to appreciate the magnitude of the problem and the limitations of surgical care.

Impact on Population Health

Scaling up basic surgical care across all sectors of the health care system in LMICs could prevent 1.4 million deaths and 77.2 million DALYs per year. The details of these preventable deaths and avertable DALYs, by superregion, are shown in tables 2.2 and 2.3. Overall, scaling up surgical care to treat four gastrointestinal diseases, four maternal-neonatal conditions, and injuries treated with simple interventions could prevent 3.2 and 3.5 percent of all deaths and DALYs, respectively, that occur each year in LMICs.

The majority of the preventable deaths were due to injuries (77 percent), followed by maternal-neonatal conditions (14 percent) and digestive diseases (9 percent). Road injury (292,000 deaths per year) and falls (184,000 deaths per year) were the two most common causes of preventable death. In the maternal-neonatal category, neonatal encephalopathy was the leading cause of preventable death (166,000 deaths per year). The South Asia and Sub-Saharan Africa superregions have the largest number of preventable deaths per year, 485,000 and 327,000 deaths, respectively.

Table 2.2 Estimated Number of Deaths per Year That Could Be Prevented If Basic Surgical Care Could Be Provided in LMICs

Surgical condition		Eastern Europe and Central Asia	Sub-Saharan Africa	Middle East and North Africa	South Asia	East Asia and Pacific	Latin America and the Caribbean	LMIC total	Major category totals (percent)
Digestive diseases	Appendicitis	1,773	14,248	1,035	1,712	3,905	3,614	26,286	145,292 (9.0)
	Gall bladder and bile duct disease	3,672	9,123	1,950	2,087	21,605	9,477	47,914	
	Hernia	3,810	816	0	4,459	1,279	3,700	14,065	
	Paralytic ileus and bowel obstruction	938	17,637	4,622	23,360	4,525	5,945	57,027	
Maternal-neonatal	Maternal hemorrhage	63	10,228	703	6,147	2,424	478	20,042	233,658 (14.4)
	Obstructed labor	8	2,248	59	8,284	255	28	10,882	
	Abortion	333	16,756	364	15,179	3,440	862	36,935	
	Neonatal encephalopathy	1,475	62,271	2,477	91,286	5,871	2,420	165,800	
Injuries	Road injury	14,342	59,218	19,832	86,610	76,976	34,894	291,872	1,042,292 (76.6)
	Other transport injury	405	3,618	633	3,325	2,220	715	10,916	
	Falls	18,731	15,823	3,224	35,239	95,405	15,148	183,570	
	Drowning	0	0	0	0	0	0	0	
	Fire, heat, and hot substances	6,772	44,754	5,016	104,373	7,583	3,922	172,421	
	Poisoning	0	0	0	0	0	0	0	
	Exposure to mechanical forces	24,602	25,333	12,094	40,270	24,560	8,370	135,229	
	Adverse effects of medical treatment	2,305	11,774	1,048	12,789	8,707	6,563	43,186	
	Animal contact (venomous)	0	0	0	0	0	0	0	
	Animal contact (nonvenomous)	491	1,508	216	802	1,335	424	4,777	
	Unintentional injuries not classified elsewhere	13,342	10,054	1,898	32,828	22,081	11,335	91,537	
	Self-harm	0	0	0	0	0	0	0	
	Interpersonal violence	9,905	21,997	3,261	16,723	12,557	44,342	108,784	
	Exposure to forces of nature	0	0	0	0	0	0	0	
	Collective violence and legal intervention	0	0	0	0	0	0	0	
Preventable deaths in LMICs		102,966	327,405	58,432	485,472	294,730	152,238	1,421,242	
Total deaths in LMICs		4,861,515	8,291,833	2,109,258	12,537,748	12,649,687	3,623,093	44,073,134	
Fraction of LMIC deaths (percent)		2.1	3.9	2.8	3.9	2.3	4.2	3.2	

Note: LMIC = low- and middle-income countries. The basic surgical care would treat four gastrointestinal diseases, four maternal-fetal conditions, and injuries that require simple interventions. Estimates are based on the assumption that surgical care could be scaled up to match the accessibility and standard of care in high-income countries across all sectors of the health care system.

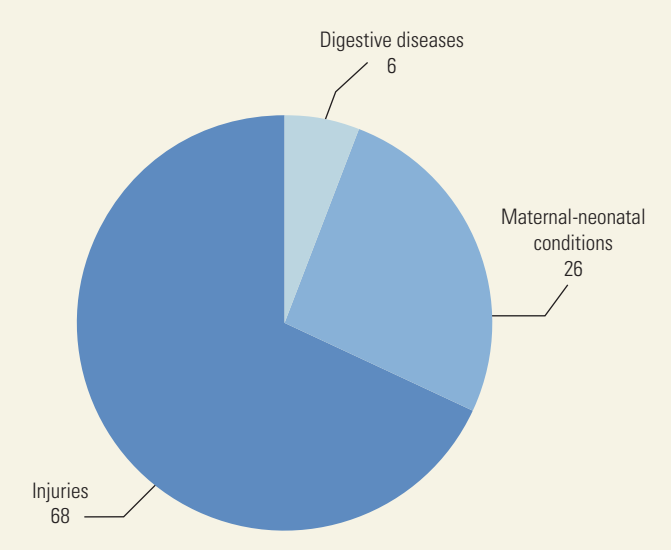
Table 2.3 Estimated Number of DALYs per Year That Could Be Averted If Basic Surgical Care Could Be Provided in LMICs

Surgical condition		Eastern Europe and Central Asia	Sub-Saharan Africa	Middle East and North Africa	South Asia	East Asia and Pacific	Latin America and the Caribbean	LMIC total	Major category totals (percent)
Digestive diseases	Appendicitis	52,513	715,487	43,104	91,989	140,253	110,468	1,153,814	4,848,078 (6.3)
	Gall bladder and bile duct disease	74,813	327,655	48,675	104,648	447,519	188,670	1,191,981	
	Hernia	68,822	37,015	0	119,929	24,260	75,281	325,308	
	Paralytic ileus and bowel obstruction	50,726	663,486	164,888	975,976	175,431	146,468	2,176,975	
Maternal-neonatal	Maternal haemorrhage	3,485	577,146	39,034	346,842	132,128	26,409	1,125,044	20,024,726 (25.9)
	Obstructed labor	439	125,618	3,230	462,367	13,636	1,543	606,833	
	Abortion	18,411	953,725	20,397	863,443	189,761	48,443	2,094,180	
	Neonatal encephalopathy	168,036	5,956,409	292,750	8,744,616	749,316	287,542	16,198,669	
Injuries	Road injury	779,308	3,507,638	1,093,122	4,692,999	4,336,877	1,691,314	16,101,257	52,316,946 (67.8)
	Other transport injury	47,120	270,686	66,709	340,760	309,928	59,125	1,094,328	
	Falls	772,809	934,208	346,824	2,031,692	3,902,220	524,038	8,511,792	
	Drowning	0	0	0	0	0	0	0	
	Fire, heat, and hot substances	270,469	3,010,660	291,629	5,559,069	403,174	173,684	9,708,685	
	Poisoning	0	0	0	0	0	0	0	
	Exposure to mechanical forces	371,523	721,882	285,019	1,422,803	394,083	147,054	3,342,364	
	Adverse effects of medical treatment	97,135	689,029	80,351	688,719	395,255	221,024	2,171,513	
	Animal contact (venomous)	0	0	0	0	0	0	0	
	Animal contact (nonvenomous)	15,857	99,707	12,394	49,961	59,451	15,136	252,507	
	Unintentional injuries not classified elsewhere	557,481	740,551	164,376	1,616,624	1,262,528	560,301	4,901,861	
	Self-harm	0	0	0	0	0	0	0	
	Interpersonal violence	461,613	1,378,702	206,024	1,043,360	761,912	2,381,028	6,232,639	
	Exposure to forces of nature	0	0	0	0	0	0	0	
	Collective violence and legal intervention	0	0	0	0	0	0	0	
Avertable DALYs		3,810,561	20,709,604	3,158,526	29,155,798	13,697,732	6,657,528	77,189,749	
Total DALYs in LMICs		160,209,494	574,216,660	122,217,565	679,620,290	525,029,717	169,976,643	2,231,270,369	
Fraction of LMIC DALYs (percent)		2.4	3.6	2.6	4.3	2.6	3.9	3.5	

Note: DALY = disability-adjusted life year; LMIC = low- and middle-income country. The basic surgical care would treat four gastrointestinal diseases, four maternal-fetal conditions, and injuries that require simple interventions. Estimates are based on the assumption that surgical care for these conditions could be scaled up to match the accessibility and standard of care in high-income countries across all sectors of the health care system.

Figure 2.2 Distribution of Burden Avertable by Scaling Up Basic Surgical Care Deliverable at First-Level Hospitals in Low- and Middle-Income Countries

Percent



Source: Data in table 2.3.

Note: Percentages are based on a surgical package that could treat four gastrointestinal diseases, four maternal-neonatal conditions, and injuries that could be managed with simple interventions.

Injuries also accounted for the largest fraction of avertable DALYs (figure 2.2). Road injury is the leading cause of injury-related avertable DALYs in LMICs (16.1 million DALYs per year) followed by fire, heat, and hot substances (9.7 million DALYs per year) (table 2.3). Of the total injury burden in LMICs, 21 percent is potentially avertable by providing basic trauma care at first-level hospitals and higher levels of care. Sub-Saharan Africa has the largest proportion of potentially avertable DALYs related to injuries (25 percent); South Asia the highest absolute number of avertable DALYs (17.4 million per year).

Of the burden associated with the maternal-neonatal conditions that we analyzed, 36 percent is potentially avertable by full coverage of quality obstetric surgery in LMICs (20.0 million DALYs). The South Asia superregion has the highest total number of avertable maternal-neonatal DALYs (10.4 million). Neonatal encephalopathy comprises the largest portion of avertable burden among the five conditions analyzed, followed by abortion (16.2 and 2.1 million DALYs, respectively).

Of the burden related to the four digestive diseases (4.8 million DALYs per year), 65 percent is potentially avertable with first-level surgical care in LMICs. Sub-Saharan Africa has the largest avertable burden in absolute DALYs (1.7 million per year) and in avertable proportion (83 percent). Paralytic ileus and intestinal obstruction accounted for the largest portion of avertable burden among the four digestive diseases (2.2 million DALYs per year; 64 percent avertable).

The majority of the burden associated with the four gastrointestinal diseases, four maternal-neonatal conditions, and injuries analyzed cannot be averted by surgical care (table 2.4). The nonavertable burden from the group (238.5 million DALYs per year; 10.7 percent of the GBD in LMICs) was 2.5 times greater than the burden averted by the basic surgical package. The majority (84 percent) of the total nonavertable burden was due to injuries (200.4 million DALYs per year), followed by maternal-neonatal conditions (34.5 million DALYs per year). Figure 2.3 shows the nonavertable burden by LMIC superregion and its relationship to the avertable burden. South Asia had the largest number of nonavertable DALYs (75.6 million DALYs per year), while the Latin American and the Caribbean superregion had the highest fraction of the total regional GBD (17.9 percent). The latter reflects the devastating earthquake in Haiti in January 2010.

BURDEN AVERTED BY SCALING UP SELECTED SUBSPECIALTY SURGICAL CARE

Rationale

Subspecialty surgical care refers to highly specialized procedures that require advanced technical skills and training. Although some third-level referral hospitals in LMICs may provide surgical care for these conditions, the advanced skills required for these procedures have prevented them being incorporated into the general health care system. Consequently, these conditions have often been managed by establishing vertical, single-procedure-based programs in LMICs, frequently supported by international funding and surgical missions. Nevertheless, because these procedures are relatively common, life changing, and often involve children, they offer a potentially large source of avertable DALYs.

Methodology

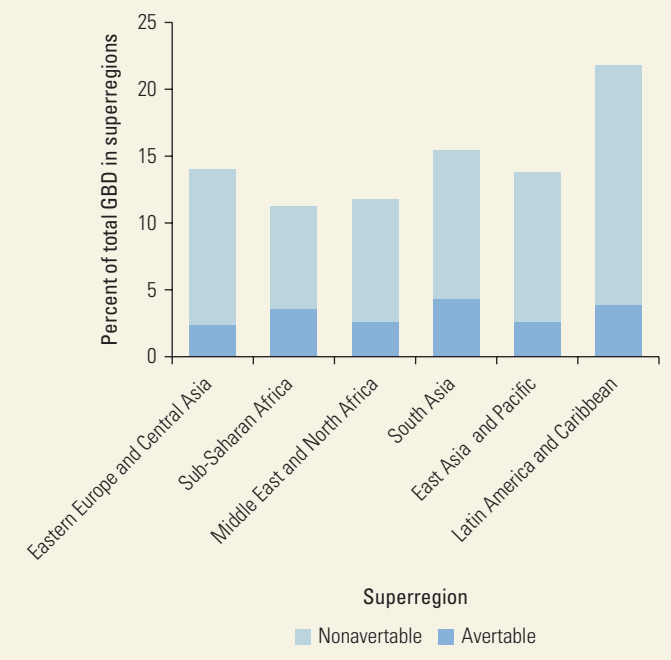
We examined five conditions: cataract, clefts (both lip and palate), congenital heart anomalies, neural tube defects, and obstetric fistula. We selected these conditions from the GBD 2010 cause list for which clearly corresponding and well-established surgical programs exist. Similar to the analysis of surgical burden at first-level hospitals, we obtained demographic and epidemiological parameters from the GBD 2010.

Table 2.4 Nonavertable Burden (DALYs) Associated with a Group of Conditions That Can Be Treated with Basic Surgical Care in LMICs

Surgical condition		Eastern Europe and Central Asia	Sub-Saharan Africa	Middle East and North Africa	South Asia	East Asia and Pacific	Latin America and the Caribbean	LMIC total	Major category totals (percent)
Digestive diseases	Appendicitis	19,536	40,564	21,724	60,541	91,505	30,921	264,791	2,569,667 (1.1)
	Gall bladder and bile duct disease	84,517	86,298	46,506	171,374	228,275	96,787	713,756	
	Hernia	24,234	50,564	27,799	101,544	136,906	37,116	378,163	
	Paralytic ileus and bowel obstruction	178,522	178,767	88,595	384,235	302,702	80,136	1,212,957	
Maternal-neonatal	Maternal hemorrhage	9,551	1,049,909	76,887	701,056	263,167	49,947	2,150,516	35,484,201 (14.9)
	Obstructed labor	100	7,962	1,700	23,261	2,495	1,106	36,624	
	Abortion	4,769	3,068	3,528	5,153	13,647	3,354	33,520	
	Neonatal encephalopathy	1,439,805	9,159,407	1,345,063	12,856,954	6,364,307	2,098,006	33,263,541	
Injuries	Road injury	3,595,438	10,438,956	3,705,845	13,102,811	18,456,805	4,236,206	53,536,062	200,495,053 (84.0)
	Other transport injury	506,046	863,473	391,651	993,914	1,253,312	334,767	4,343,163	
	Falls	2,100,073	3,087,910	1,247,749	6,769,471	5,823,690	1,345,565	20,374,457	
	Drowning	1,280,302	3,241,397	699,575	7,152,853	5,518,534	1,234,016	19,126,677	
	Fire, heat, and hot substances	499,174	2,811,538	358,772	3,928,508	907,600	303,034	8,808,626	
	Poisoning	817,934	1,502,573	345,178	3,437,583	2,009,199	150,428	8,262,895	
	Exposure to mechanical forces	1,184,059	1,496,743	544,190	2,377,539	1,620,976	339,263	7,562,770	
	Adverse effects of medical treatment	169,265	232,522	135,416	201,614	349,494	280,437	1,368,748	
	Animal contact (venomous)	41,796	923,985	55,456	1,403,954	179,762	103,217	2,708,170	
	Animal contact (nonvenomous)	17,706	363,505	15,345	165,198	77,752	16,669	656,174	
	Unintentional injuries not classified elsewhere	1,332,066	2,079,247	649,305	3,462,963	3,581,777	942,741	12,048,099	
	Self-harm	3,792,899	2,175,157	735,231	14,721,081	8,472,490	1,775,160	31,672,018	
	Interpersonal violence	1,578,109	3,950,824	683,929	3,034,727	2,980,006	5,590,425	17,818,020	
	Exposure to forces of nature	0	5,519	0	0	0	11,373,271	11,378,790	
	Collective violence and legal intervention	6,228	179,868	61,659	582,628	0	0	830,383	
Nonavertable DALYs		18,682,128	43,929,755	11,241,103	75,638,960	58,634,402	30,422,573	238,548,921	
Total DALYs in LMICs		160,209,494	574,216,660	122,217,565	679,620,290	525,029,717	169,976,643	2,231,270,369	
Fraction of LMIC DALYs (percent)		11.7	7.7	9.2	11.1	11.2	17.9	10.7	

Note: DALY = disability-adjusted life year; LMIC = low- and middle-income countries. The group includes four digestive diseases, four maternal-fetal conditions, and injuries that can be treated with simple interventions. The nonavertable burden refers to the burden associated with a particular condition that is not preventable or reversible with surgical care.

Figure 2.3 Burden Associated with a Group of Conditions That Can Be Treated with Basic Surgical Care in Low- and Middle-Income Countries



Source: Data from tables 2.3 and 2.4.
Note: GBD = global burden of disease. The group includes four gastrointestinal diseases, four maternal-neonatal conditions, and injuries that can be managed with simple interventions. Results are expressed as the percentage of the total superregion global burden of disease.

The burden of obstetric fistula and cataract in the GBD 2010 comprised YLDs only. We estimated the burden of fistula in the counterfactual state by adjusting the successful closure rate of surgical repair with the risk of residual urinary incontinence that may take over:

$$YLDcf_{age,\,gender}^{superregion} = Prevalence_{age,\,gender}^{superregion} \times (1 - SuccessRate) \times DW^{fistula} + SuccessRate \times UIRate \times DW^{urinary\ incontinence}, \quad (2.6)$$

in which *SuccessRate* is the successful closure rate and *UIRate* the risk of urinary incontinence after surgery.

The burden of cataract in its counterfactual state was calculated by assuming that the lowest age- and sex-specific YLD rates per capita reflect the counterfactual situation:

$$Pop'n_{age,\,gender}^{superregion} \times YLDRate_{age,\,gender}^{lowest\ from\ all\ regions}, \quad (2.7)$$

where *Pop'n* is the population in each superregion, and *YLDRate* the per capita YLD of cataract in each region.

For congenital anomalies, we first estimated the nonfatal burden if the counterfactual surgical coverage could be provided in LMICs. This estimation was made by assuming that the difference in prevalence between a particular age group and the age group immediately following that in the high-income superregion reflects the excess mortality for the counterfactual surgical coverage. Beginning with the birth prevalence that varies between LMIC regions, we applied this assumption to age one year and above to follow the prevalence. The resulting prevalence for each gender and age was then multiplied by the disability weights of each condition to derive the YLDs. Next, we estimated the fatal burden attributable to congenital anomalies in the counterfactual situation. We then estimated the YLLs and DALYs for the counterfactual state in the same manner as we did in our analysis of basic surgical care in the previous section. Finally, the avertable burden was calculated using equation (2.1).

Because it is well known that persons with congenital anomalies, especially those without access to treatment, are at risk for any number of other fatal complications, such as malnutrition or pneumonia, we performed an additional analysis to more accurately quantify the avertable burden of cleft lip and palate, congenital heart anomalies, and neural tube defects. This step was necessary because deaths and YLLs for congenital anomalies reported in the GBD 2010 are limited to only those deaths for which the underlying cause is coded as being due to congenital conditions. Furthermore, natural history modeling of the GBD 2010 data shows a sharp decline in the prevalence of non-operated cases compared with those who received operations. The excess number of deaths compared with the number predicted by the cause-code deaths and YLLs clearly illustrate this excess mortality phenomenon. Accordingly, to avoid underestimating the potential impact of surgical care in treating congenital anomalies, we based our avertable DALY estimates on the excess mortality related to all causes, not only the DALYs reported for a particular congenital anomaly in the GBD study. Additional details on how these burden calculations were performed can be found in manuscript B listed in annex 2F.

Impact on Population Health

Scaling up selected subspecialty surgical care in LMICs could prevent 388,000 deaths and avert 38.9 million DALYs per year. The details of these preventable deaths and avertable DALYs, by superregion, are shown in table 2.5. This impact, although smaller than the total burden averted by scaling up basic surgical care, is still substantial and could increase the number of surgically preventable deaths and DALYs by 27.3 and 50.4 percent, respectively. Overall, scaling up surgical care to treat cataract, cleft lip and palate, congenital heart anomalies,

Table 2.5 Estimated Number of Preventable Deaths and Avertable, and Nonavertable DALYs Associated with Scaling Up Selected Subspecialty Surgical Care

Surgical condition		Eastern Europe and Central Asia	Sub-Saharan Africa	Middle East and North Africa	South Asia	East Asia and Pacific	Latin America and the Caribbean	LMIC total	Fraction of total (percent)
Preventable deaths	Cataract	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Cleft lip and palate	1,915	16,863	8,330	21,905	13,631	3,004	65,648	16.9
	Congenital heart anomalies	4,844	89,231	21,742	99,414	32,905	8,045	256,180	66.0
	Neural tube defects	500	18,162	5,395	39,934	1,736	619	66,346	17.1
	Obstetric fistula	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Total preventable deaths	7,259	124,256	35,467	161,253	48,273	11,668	388,174	
	Total deaths in LMICs	4,861,515	8,291,833	2,109,258	12,537,748	12,649,687	3,623,093	44,073,134	
	Fraction of LMIC deaths (percent)	0.2	1.5	1.7	1.3	0.4	0.3	0.9	
Avertable DALYs	Cataract	306,592	306,441	288,451	2,043,146	988,834	274,295	4,207,758	10.8
	Cleft lip and palate	147,661	1,447,813	601,006	1,705,359	965,032	209,701	5,076,572	13.0
	Congenital heart anomalies	442,648	7,726,243	1,898,098	8,938,691	2,893,186	697,631	22,596,497	58.1
	Neural tube defects	46,399	1,602,477	495,807	3,669,764	175,503	57,880	6,047,830	15.5
	Obstetric fistula	1,525	415,241	50,472	225,218	298,628	5,471	996,553	2.6
	Total avertable DALYs	944,823	11,498,214	3,333,834	16,582,177	5,321,183	1,244,978	38,925,209	
	Total DALYs in LMICs	160,209,494	574,216,660	122,217,565	679,620,290	525,029,717	169,976,643	2,231,270,369	
	Fraction of LMIC DALYs (percent)	0.6	2.0	2.7	2.4	1.0	0.7	1.7	
Nonavertable DALYs	Cataract	69,600	41,459	31,647	115,320	222,271	49,772	530,068	1.1
	Cleft lip and palate	54,930	250,262	75,040	311,746	232,878	54,035	978,889	2.1
	Congenital heart anomalies	1,116,728	14,502,230	3,046,252	15,196,430	5,229,279	1,903,422	40,994,342	88.1
	Neural tube defects	66,776	1,073,060	295,829	1,763,196	611,067	110,549	3,920,477	8.4
	Obstetric fistula	191	51,998	6,320	28,202	37,395	685	124,791	0.3
	Total nonavertable DALYs	1,308,225	15,919,009	3,455,087	17,414,894	6,332,890	2,118,463	46,548,568	
	Total DALYs in LMICs	160,209,494	574,216,660	122,217,565	679,620,290	525,029,717	169,976,643	2,231,270,369	
	Fraction of LMIC DALYs (percent)	0.8	2.8	2.8	2.6	1.2	1.2	2.1	

Note: DALY = disability-adjusted life year; LMIC = low- and middle-income countries. Estimates are based on the assumption that care for cataract, cleft lip and palate, congenital heart anomalies, neural tube defects, and obstetric fistula could be scaled up to match the accessibility and standard of care in high-income countries. Estimates for cleft lip and palate, congenital heart anomalies, and neural tube defects account for the excess mortality due to any cause. n.a. = not applicable.

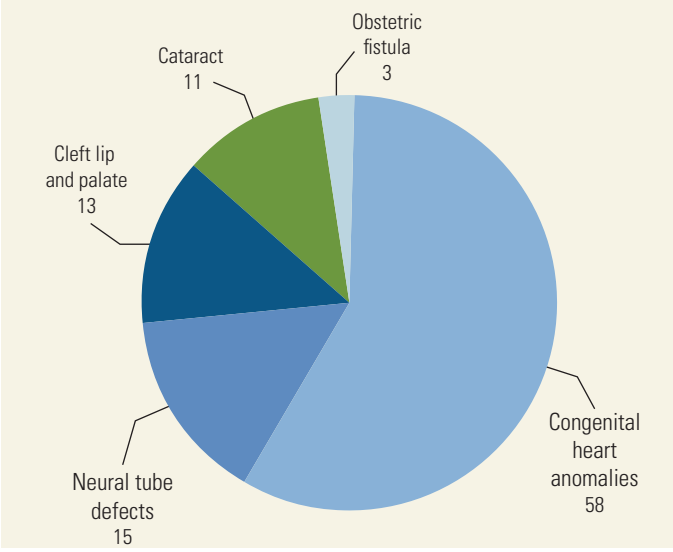
neural tube defects, and obstetric fistula could prevent 0.9 and 1.7 percent of all deaths and DALYs, respectively, that occur each year in LMICs.

The largest number of preventable deaths occurred in the congenital heart anomalies category (66 percent), followed by neural tube defects (17 percent). This finding may underestimate the actual mortality because not all deaths are necessarily coded to these causes. Figure 2.4 shows the distribution of the burden that could be averted by scaling up advanced surgical treatment of cataract, cleft lip and palate, congenital heart anomalies, neural tube defects, and obstetric fistula. These avertable DALY estimates, which include the correction for the excess mortality due to other causes, shows that the majority of avertable burden would result from scaling up surgical care to treat congenital heart anomolies (58 percent) and neural tube defects (15 percent). The South Asia and Sub-Saharan Africa superregions have the highest total number of avertable DALYs per year, 16.6 million and 11.5 million, respectively; the Eastern Europe and Central Asia superregion has the least (945,000 DALYs per year).

The subspecialty surgical care we analyzed is better at addressing burden compared with basic surgical care provided at first-level hospitals. Of the burden associated with cataract, cleft lip and palate, congenital heart anomalies, neural tube defects, and obstetric fistula, 46 percent is avertable with surgical care, compared with 24.1 percent of the burden related to the gastrointestinal diseases, maternal-neonatal conditions, and injuries we analyzed. An advantage of subspecialty surgical care is that it can be planned, is usually reproducible, and can be done on an elective basis.

Figure 2.4 Distribution of Burden That Could Be Averted by Scaling Up Selected Subspecialty Surgical Care in Low- and Middle-Income Countries

Percent



Source: Data from table 2.5.

Note: Percentages are based on surgical care that would treat cataracts, cleft lip and palate, congenital heart anomalies, neural tube defects, and obstetric fistula.

LIMITATIONS OF CURRENT ANALYSIS

Our methodology relied on the assumption that the lowest fatality and disability estimates for persons with surgically treatable conditions from the 21 epidemiological regions reflect the case of full surgical coverage. The estimates of impact of full coverage on disease burden were from high-income regions, and whether these figures are applicable to other settings is not clear.

Even if geographic and financial barriers to surgical care are removed, health-seeking behavior may vary substantially among contexts. The nontrivial variations of fatality rates among HICs suggest that none of the health systems truly reflect the counterfactual state, although differences in coding practices and data-gathering mechanisms may contribute to the variations.

In addition to full population coverage, the quality of surgery and anesthesia is a critical precondition of this analysis that, if compromised, could separately add to excess mortality.

We may also be overestimating the burden that could be averted with first-level surgical care because our analysis is based on the lowest rates of case fatality and disability in HICs. In HICs, the sickest patients are often transferred to higher levels of care where they benefit from advanced care provided in intensive care units—this higher level of care is often not available in LICs, resulting in higher fatality rates.

Furthermore, the parameters for our analysis are primarily from the GBD 2010. This is a major advantage in that our results are thus directly comparable with those from the GBD 2010, but it also implies that our analysis is fully prone to the GBD 2010's limitations.

Finally, we did not attempt to make any estimates of uncertainty. Uncertainty estimates are reported in the GBD 2010, but to propagate these estimates through to our analysis did not seem practical given that we needed to make numerous assumptions to arrive at our results.

WHERE SURGICAL CARE FITS AMONG GLOBAL HEALTH PRIORITIES

LMICs are increasingly using burden-of-disease data to allocate limited resources and to prioritize funding for research and treatment programs at the global level.

Table 2.6 Public Health Impact of Scaling Up Surgical Care in Low- and Middle-Income Countries

Type of surgical care	Preventable deaths (millions)	Burden			
		Avertable		Nonavertable	
		DALYs per year (millions)	Fraction of LMIC total GBD (percent)	DALYs per year (millions)	Fraction of LMIC total GBD (percent)
Basic surgical care[a]	1.4	77.2	3.5	238.5	10.7
Subspecialty surgical care[b]	0.4	38.9	1.7	46.5	2.1
Totals	1.8	116.1	5.2	285.0	12.8

Note: DALY = disability-adjusted life year; GBD = global burden of disease; LMIC = low- and middle-income countries.
a. Designed to treat four gastrointestinal diseases, four maternal-fetal conditions, and injuries that can be managed with simple interventions. Basic surgical care refers to emergency and essential surgical care that is deliverable with the resources available at first-level hospitals.
b. Surgical care for cataract, cleft lip and palate, congenital heart anomalies, neural tube defects, and obstetrical fistula.

It is important that our burden estimates be properly represented and interpreted. Table 2.6 summarizes the potential impact on public health in LMICs if surgical care could be scaled up to meet the standard of care and accessibility that exists in HICs. Included in the table are our estimates of the number of preventable deaths and surgically avertable and nonavertable DALYs and their respective fraction of the total GBD in LMICs. Overall, our analysis suggests that scaling up basic and selected subspecialty surgical care could avert 5.2 percent of the total burden of disease in LMICs.

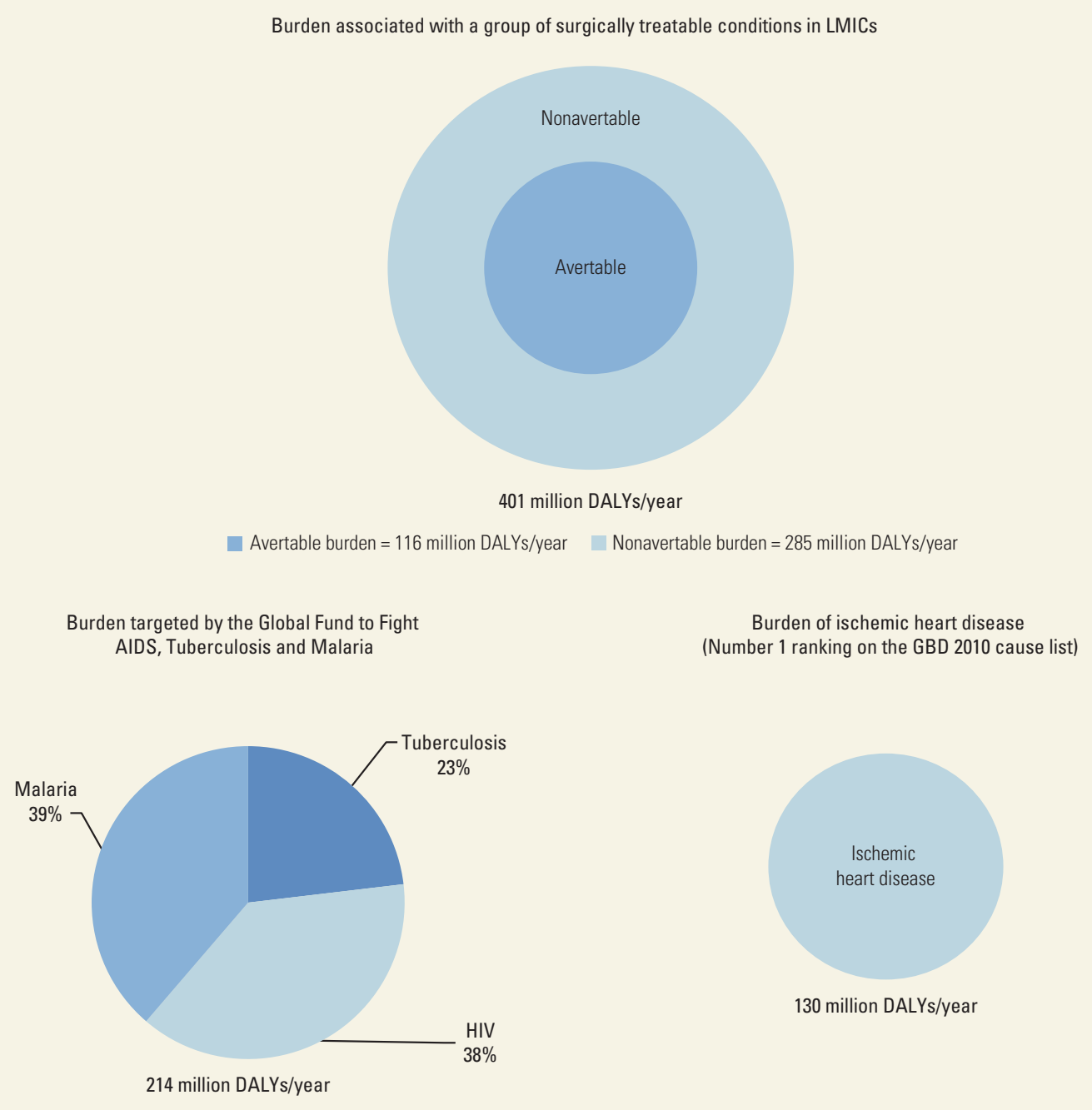
Care should be exercised in interpreting this 5.2 percent figure because it does not represent the global surgical burden or the total burden that could be averted by surgical care in LMICs. To estimate a global surgical burden, it would be necessary to extend our analysis to include surgical care provided in HICs. It would also be necessary to account for the almost 20 percent of patients in our NIS database analysis whose primary diagnoses were not captured by the GBD 2010 cause list. A more complete assessment of the burden that could be averted by surgical care in LMICs would need to include the following:

- Care for other common surgical conditions that could be or is already being, done at first-level hospitals, for example, treatment of surgical infections such as incision and drainage of abscesses, tube thoracostomy for empyema, irrigation of septic joints, and sequestrectomy for chronic osteomyelitis
- Surgical care provided at second- and third-level hospitals, for example, complex gastrointestinal surgery, resection of tumors, and major pediatric surgical procedures

Given what seems like the ability to prevent only a small fraction of total GBD in LMICs, how then does surgical care fit among other global health priorities? To address this question, we compared our surgical burden estimates to the global burden of tuberculosis, HIV/AIDS, malaria, and ischemic heart disease. These four conditions were selected because they are currently recognized as some of our most important global health problems. Ischemic heart disease (129.8 million DALYs) ranks first on the GBD 2010 cause list (Murray, Vos, and others 2012). The other three have been the targets of the Global Fund to Fight AIDS, Tuberculosis and Malaria since 2002. Because patients with tuberculosis, HIV/AIDS, and ischemic heart disease may sometimes require surgical care, it is important to not interpret this simply as a comparison between surgical and nonsurgical conditions; rather, it is intended to illustrate the magnitude of the disease burden amenable to a select number of surgical interventions.

Figure 2.5 illustrates the burden of high-priority global health problems and compares them with our surgical burden estimates. The avertable burden from scaling up basic surgical care at first-level hospitals and advanced care in specialized clinics in LMICs (116.1 million DALYs per year) exceeds the unaddressed global burdens of HIV/AIDS (81.6 million DALYs), tuberculosis (49.4 million DALYs), or malaria (82.7 million DALYs) individually, but it is less than the unaddressed burden associated with ischemic heart disease (130.0 million DALYs per year). Perhaps a better comparison would be between the burden that could be addressed with surgical care and the burden that could be averted by treatment of the other conditions—for example, the burden averted by antiretroviral medication to treat HIV—but these data do not exist.

Figure 2.5 Burden of Important Global Health Problems



Note: DALY = disability-adjusted life year; GBD 2010 = Global Burden of Disease 2010. Area of circles represents the relative number of DALYs per year. The "avertable burden" area depicts the burden that could be averted by scaling up surgical care in low- and middle-income countries (basic surgical care that can be delivered at first-level hospitals and selected subspecialty surgical care). The burden averted from scaling up surgical care (116.1 million DALYs per year) exceeds the global burden of HIV/AIDS (81.6 million DALYs per year) and malaria (82.7 million DALYs per year). The total burden associated with the surgical conditions analyzed is almost twice the burden targeted by the Global Fund to Fight AIDS, Tuberculosis and Malaria.

Just as not all of the HIV (or other disease burden) can be addressed with currently available treatments, the magnitude of the nonavertable surgical burden should be interpreted as providing crucial direction for development of strategies to prevent and more effectively treat these conditions. To place the nonavertable surgical burden (285 million DALYs per year) in perspective, that number is more than twice that associated with ischemic heart disease; it is more than 1.3 times larger than the total burden targeted by the Global Fund to Fight AIDS, Tuberculosis and Malaria. Given that the largest portion of this nonavertable burden is related to injuries (200.5 million DALYs per year; 70.3 percent of the nonavertable burden), development of injury prevention programs and improvement of prehospital care for injured patients in LMICs are critical. To provide the best possible care for our patients, we must advocate for a comprehensive strategy that includes both surgical and nonsurgical interventions.

In conclusion, surgically treatable conditions are an important public health problem in LMICs; the magnitude of avertable burden exceeds the burden of some of the most widely recognized global health problems.

FUTURE DIRECTIONS

Health Systems and Performance of Surgical Services

Global health initiatives have often struggled to implement changes at scale. It is reasonable to expect that scaling up surgical care in LMICs will face similar problems unless the understanding of the factors that determine the performance of surgical services is improved. Performance refers to the ability of the surgical service to deliver safe, effective, accessible, and cost-efficient care—and ultimately whether that surgical service meets the needs of the population. A health system encompasses the individuals, organizations, and processes—from the national government to the private sector to community-based organizations—that focus primarily on ensuring health outcomes (WHO 2007). Surgery performance can vary markedly in different health systems, even at similar levels of health care expenditure.

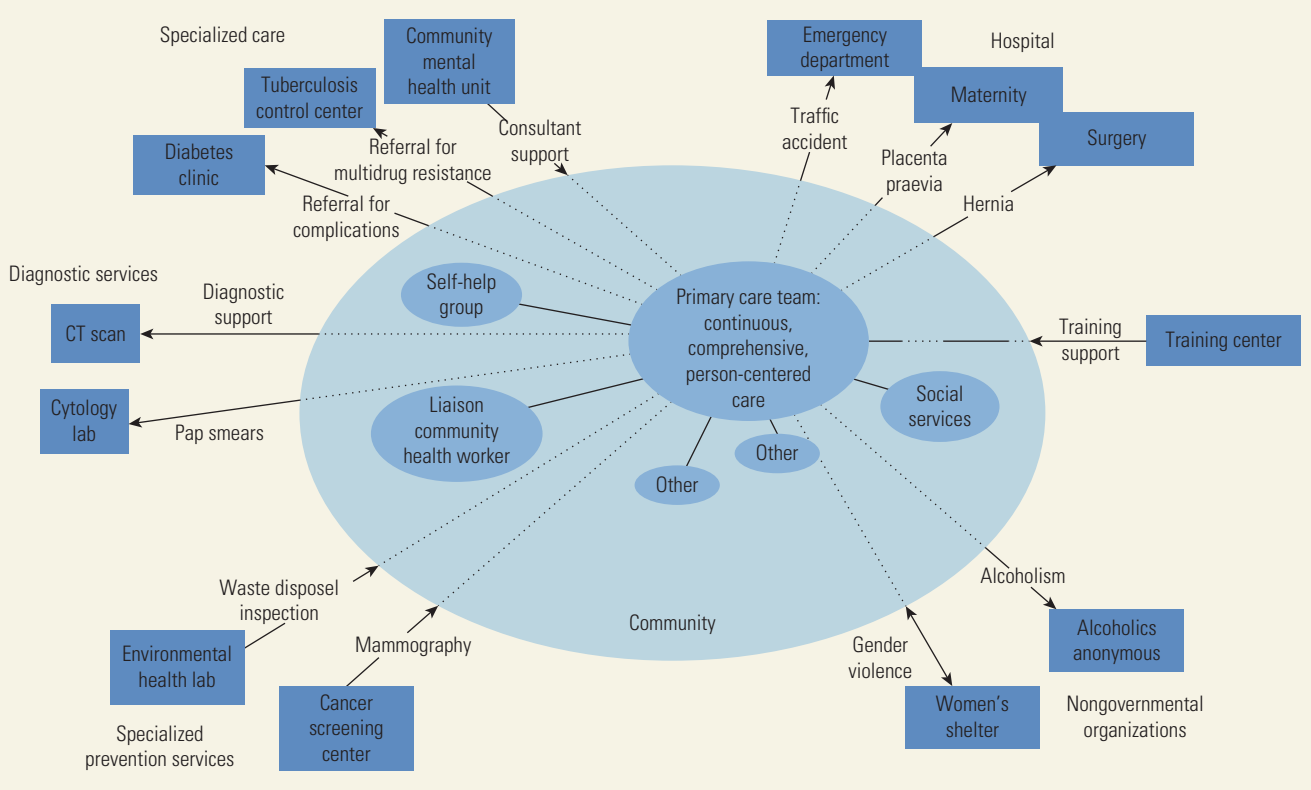
The recent focus on strengthening health systems in LMICs (Mills, Rasheed, and Tollman 2006; Palen and others 2012), and, in particular, the role of primary health care, means that this is an opportune time to develop strategies for examining the performance of surgical services. An evolving theme is that surgical care is an essential component of primary health care (WHO 2008). In the new conceptual model, primary health care is viewed as a hub of coordination within the health system, with the first-level hospital serving as one of many components (figure 2.6). The challenge for surgery is to integrate the organizational structure of surgical care into the larger health system and to concurrently develop methods for measuring its performance. Meeting this challenge will require moving beyond the reductionist view that surgical care is simply a collection of components that includes infrastructure, human resources, financing, and supplies. A more comprehensive view is needed, one that recognizes that surgical care is part of a larger health system in which performance is determined by critical interrelationships.

Research and Development Goals

The literature on surgical care in LMICs is growing rapidly. Nevertheless, major knowledge gaps remain, especially related to optimal strategies for delivering surgical care at first-level hospitals and measuring its impact. Based on the work done in preparing this chapter, the following are some of the areas that require investments in research and development.

- *Improved methodology for assessing the public health impact of surgical care.* As noted by Gosselin, Ozgediz, and Poenaru (2013) and further illustrated by the challenges we encountered in trying to estimate a global burden of surgical disease, DALY-based approaches may not be the best metric for global surgery or for measuring the impact of surgical interventions. The ideal metric would be simple to measure, oriented toward quantifying outcomes of interventions, and easy for policy makers and health planners to interpret. Alternatives include measurement of disease prevalence, backlogs in treatment, disability incurred by delays in care, and value of a statistical life (Gosselin, Ozgediz, and Poenaru 2013). The value of a statistical life is of particular interest because it widens the spectrum of tools available to estimate the cost-effectiveness of surgical care (Corlew 2010). Research is needed to explore these and other alternatives and to determine their utility in HICs as well as LMICs.
- *Better estimates of the avertable and nonavertable burden of surgically treatable conditions in LMICs.* Although population-based countrywide surgical surveys in LMICs have been undertaken (Groen and others 2013; Petroze and others 2013), these data are not of sufficient detail to be used in GBD calculations. Data collection needs to be standardized so that data generated in community-based surveys can be used in future GBD studies.

Figure 2.6 Primary Care as a Hub of Coordination: Networking within the Community Served and Outside Partners



Source: WHO 2008.
Note: CT = computed tomography. The emergency, maternity, and surgery departments are included as essential components.

Moreover, these data could be used to support the case for expanding the purview of future GBD studies. Because our analysis was based heavily on methodological assumptions, our estimates need to be validated. Validation could perhaps be undertaken in prospective pilot studies from a sample of hospitals or populations, or by comparing appropriately matched hospitals in high- and low-income settings.

- *Identified strategies to address the nonavertable surgical burden.* One of the most important findings in our study was that the majority of the surgical burden is currently nonavertable. Nonavertable does not necessarily imply a problem that cannot be addressed; the nonavertable burden can be reduced through nonsurgical means, such as injury prevention, improved delivery of care, or innovation. Research priorities include a more detailed analysis of the nonavertable burden, ways in which injury prevention strategies can best be implemented in settings of limited resources, and identification of areas in which surgical innovation might have the greatest impact in LMICs.
- *Tools to assess surgical care within primary health care systems.* Although the development of indicators for monitoring and evaluating project and system performance is commonplace within health and economic development programs, this process has not been applied in a systematic way to the field of essential and emergency surgery in LMICs. One approach might be to adapt the WHO's *Monitoring the Building Blocks of Health Systems* Monitoring and Evaluation Matrix (MBBHS M&E Matrix) (WHO 2010) or similar tool for surgical care. Within the MBBHS M&E Matrix are health system building blocks that represent discrete areas of policy making, inputs into the health system, and direct outputs. Improvements in the health system are measured in four domains: improved health, responsiveness, social and financial risk protection, and improved efficiency. The MBBHS M&E strategy seeks to create government accountability for progress and performance toward health goals, to facilitate results-based financing of health programs, to measure the impact of interventions and inputs, and to create sustainable

measurement strategies (WHO 2010). The matrix provides a comprehensive strategy for assessing the function of primary health care systems, but it has not been adapted to monitor and evaluate surgical care. Adapting the MBBSHS M&E Matrix or a similar framework for assessing surgical care in LMICs could help facilitate surgery's integration into health systems and simultaneously provide a mechanism for measuring its performance.

- *Models of how surgical care can best be implemented in LMICs*. Perhaps the most pressing research need in global surgery is to determine how emergency and essential surgical services can best be implemented in countries where the needs are greatest and where health systems are least developed. At present, far too few examples of well-functioning surgical services in LMICs can be found, and little research on what factors make them successful has been conducted. Scaling up surgical care in LMICs requires much more than theater personnel, equipment, and infrastructure; it also requires education and training, functioning methods and processes, data systems, and an enabling environment (Akenroye, Adebona, and Akenroye 2013). Research priorities include the design of a basic surgical package that is flexible enough to be adapted to local needs, benchmarks to assess what is required for health systems to deliver emergency and essential surgical care at first-level hospitals, strategies for measuring the impact of the improvements, and most important, cost estimates.
- *Research to better understand the surgical workforce needs in LMICs*. One of the greatest challenges of scaling up surgical care worldwide lies in deficiencies in the supply, training, and distribution of human resources. Training surgeons takes time and is expensive; once qualified, they are reluctant to serve in rural first-level hospitals where the needs are greatest. Nonetheless, various countries have successfully trained doctors to perform surgical care in rural areas (Sani and others 2009); in other cases, countries have introduced nonphysician cadres specializing in surgery. Mozambique, for example, began training nonphysician surgeons (*técnicos de cirurgia*) in 1984, a program involving a three-year degree (Cumbi and others 2007; Pereira and others 2007; Vaz and others 1999). Important questions remain regarding how surgical providers in LMICs should be trained, their scope of practice, and how best to assess their surgical skills.
- *Studies to define how quality of surgical care affects the entire health service*. Assessment of surgical care in settings of limited resources has typically focused on physical and human resources and has neglected the process and outcomes components. However, understanding how the physical and human resources affect processes and outcomes is necessary to gain a proper understanding of the factors that determine quality of care. The link between quality of surgical care and the public's perception of the health system needs further study.
- *Initiatives to better align surgical care with other global health movements*. Surgery has an important role in meeting the 2015 United Nations Millennium Development Goals (PLoS Medicine Editors 2008). Scaling up surgical care in LMICs will be required if infectious, child, and maternal mortality rates are to be brought down to universally low rates by 2035 (Jamison and others 2013). No detailed studies have been made of the role surgical care has in meeting the Millennium Development Goals and Global Health 2035 targets. Because both initiatives link health improvement to economic growth, integrating surgical care into these important movements could be an important strategy for encouraging investment in surgical care in LMICs.

ANNEXES

The annexes to this chapter are as follows. They are available at http://www.dcp-3.org/surgery:

- Annex 2A. ICD-9 Codes Included in the GBD 2010 Study
- Annex 2B. The Role of Surgery in Global Health: Analysis of United States Inpatient Procedure Frequency by Condition Using the Global Burden of Disease 2010 Framework
- Annex 2C. AHRQ ICD-9 Procedure Codes
- Annex 2D. Surgical Procedures Required to Treat the GBD 2010 Causes Included in the Basic Surgical Care Scale-Up Model
- Annex 2E. Adjustments to Account For The Burden Not Amenable to Surgical Care
- Annex 2F. Additional Details on How Burden Calculations Were Performed

1. Higashi, H., J. J. Barendregt, N. J. Kassebaum, T. G. Weiser, S. W. Bickler, and others. 2014. "Burden of Injuries Avertable by a Basic Surgical Package in Low- and Middle-Income Regions: A Systematic Analysis from the Global Burden of Disease 2010 Study." *World Journal of Surgery* 39 (1):1–9. doi:10.1007/s00268-014-2685-x.
2. Higashi, H., J. J. Barendregt, N. J. Kassebaum, T. G. Weiser, S. W. Bickler, and others. 2014. "The Burden of Selected Congenital Anomalies Amenable to Surgery in Low and Middle-Income Regions: Cleft Lip and Palate, Congenital Heart Anomalies and Neural Tube Defects." *Archives of Disease in Childhood*. September 26. Electronic publication ahead of print.
3. Higashi, H., J. J. Barendregt, N. J. Kassebaum, T. G. Weiser, S. W. Bickler, and others. 2014. "Surgically-Avertable Burden of Digestive Diseases at First-Level Hospitals in Low and Middle-Income Regions." *Surgery*. October 22. Electronic publication ahead of print.

4. Higashi, H., J. J. Barendregt, N. J. Kassebaum, T. G. Weiser, S. W. Bickler, and T. Vos. 2015. "Surgically-Avertable Burden of Obstetric Conditions in Low and Middle-Income Regions: A Modelled Analysis." *BJOG* 122 (2): 228–36.

- Annex 2G. WHO Monitoring the Building Blocks of Health Systems

NOTES

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The World Bank classifies countries according to four income groupings. Income is measured using gross national income (GNI) per capita, in U.S. dollars, converted from local currency using the *World Bank Atlas* method. Classifications as of July 2014 are as follows:

- Low-income countries (LICs) = US$1,045 or less in 2013
- Middle-income countries (MICs) are subdivided:
  - Lower-middle-income = US$1,046 to US$4,125
  - Upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more

1. The National (Nationwide) Inpatient Sample (NIS), 2010, Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality, Rockville, MD, http://www.hcup-us.ahrq.gov/db/nation/nis/nisdbdocumentation.jsp.
2. *Basic surgical care* refers to emergency and essential surgical care that can be provided with the resources available at first-level hospitals. Because emergency and essential surgical care is often provided at higher levels of care—secondary and tertiary hospitals—our estimates are based on the effects of scaling up basic surgical care across all sectors of the health care system.
3. Paralytic ileus is grouped with intestinal obstruction in GBD 2010.

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