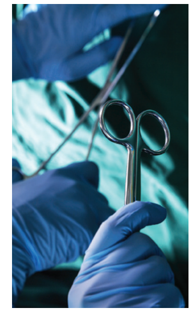

Chapter 16

Excess Surgical Mortality: Strategies for Improving Quality of Care

Thomas G. Weiser and Atul Gawande

GLOBAL VOLUME AND SAFETY OF SURGICAL CARE

The World Health Organization (WHO) has estimated that 234 million operations are performed worldwide each year (Weiser and others 2008). The WHO's analysis establishes three significant findings:

- Surgical interventions take place on a massive and previously unrecognized scale in all countries and resource settings.
- The inequity in service provision among countries and settings is dramatic.
- Little is known about the indications for, and the quality, safety, and outcomes of, surgical care.

Much has since been done to investigate these issues. The WHO has provided guidance for measuring surgical services and capacity through a set of standardized metrics for surgical surveillance (Weiser and others 2009). In addition, a situational analysis tool has been constructed and deployed in a number of countries to help assess surgical capacity (WHO 2010). Yet the logistics of performing surgery are complex and demand standardization. Surgical services must also continuously measure patient outcomes to identify shortcomings, inform improvements, and maintain high levels of quality care.

Mortality Following Surgery

The annual volume of surgery is almost twice that of obstetrical deliveries, and surgical death rates far surpass maternal mortality rates. Global estimates suggest that at least 7 million people suffer complications following surgery each year, including at least 1 million deaths, a magnitude that exceeds both maternal and AIDS-related mortality. As many as 50 percent of these deaths and complications are preventable (Weiser and others 2008). Surgical care is fraught with hazards in every setting; patients face immediate danger from both the technical risks of the procedures themselves and the anesthesia needed to induce insensibility and sedation.

Studies from high-income countries (HICs) confirm high rates of postoperative mortality and high variability in those rates. In the Netherlands, a review of 3.7 million inpatient surgical procedures at 102 hospitals over 15 years reveals a perioperative mortality rate of 1.85 percent (Noordzij and others 2010). A similar inpatient surgical death rate has been noted in the United States, with all-cause postoperative mortality in 2006 estimated to be 1.14 percent to 1.32 percent (Semel and others 2012; Weiser and others 2011). Pearse and others (2012) studied the outcomes of one week of inpatient surgery (excluding cardiac, neurosurgical, radiological, and obstetric procedures) in 498 hospitals in 28 European countries. The in-hospital crude

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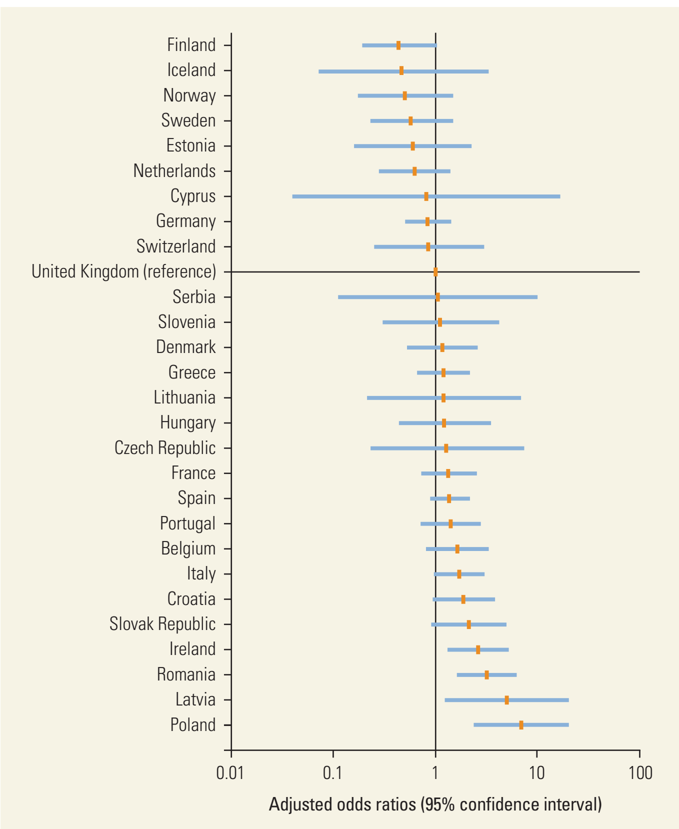
postoperative mortality ranged from 1.2 percent in Iceland to 21.5 percent in Latvia. After adjusting for patient age, the American Society of Anesthesiologists's score of patient fitness for surgery, the urgency of surgery, the extent of surgery (minor, intermediate, or major), the specialty, and the presence of metastatic disease or cirrhosis, the odds ratios for death following surgery—using the United Kingdom as reference—ranged from a low of 0.44 in Finland to a high of 6.92 in Poland (figure 16.1). Overall, the researchers noted a 4 percent in-hospital crude mortality rate in this sample of more than 46,000 surgical cases, a previously unreported and unexpectedly high number.

Disparity of Service Provision

Nearly 60 percent of all operations take place in HICs, where 15 percent of the world's population lives (table 16.1). Low-income countries (LICs) account for nearly 35 percent of the global population, yet only 3.5 percent of all surgical interventions (Weiser and others 2008). This lack of equity in access to surgical interventions demands further investigation.

Figure 16.1 Adjusted Odds Ratio for In-Hospital Mortality Following Surgery in 28 European Countries, 2011



Source: Pearse and others 2012.

The extent of unmet need in resource-poor settings remains unclear, but basic surgical services are increasingly recognized as essential for relieving suffering and sustaining health. Surgery is critical for obstetrical emergencies; common congenital conditions, such as clubfoot; traumatic injuries, including orthopedic injuries; and treatment of abscesses, cancers, hernias, and cataracts. Maternal health advocates estimate that an optimum rate of cesarean section is at least 5 percent of all births to avert high rates of death of mothers and children (Dumont and others 2001), but similar minimum criteria have not been proposed for basic surgical services to address the disease burden in a population.

It has, however, become clear that surgical care is an essential component of effective health delivery systems and vital for enabling long and healthy life. In a population-based survey in Sierra Leone, one of the poorest countries in the world, one in every four respondents reported needs that might benefit from surgical consultation (Groen and others 2012). In addition, almost one in three households had experienced a death within the past year; of these households, one in four had a condition within the week preceding death that likely could have been treated surgically: abdominal distention, bleeding or complications following childbirth, an acute or chronic wound, a mass, or an acquired or congenital deformity. This survey indicates a tremendous unaddressed disease burden that might be mitigated with improved access to surgical care.

Limitations in the Scope of Practice in LMICs

Surgical interventions are performed at much lower frequency in the resource-poor settings of low- and middle-income countries (LMICs) and under more limited circumstances. Typically, rural first-level hospitals and even third-level public hospitals have a high-percentage of urgent cases; these facilities focus on a limited set of interventions, given their resource constraints. For example, studies from LMICs have shown very high ratios of cesarean section compared with other types of surgical procedures. Cesarean section has been found to represent a substantially higher proportion of all surgical interventions in Sierra Leone (42 percent), Zambia (40 percent), Uganda (34 percent), Niger (26 percent), Malawi (23 percent), and Haiti (12 percent) than in Organisation for Economic Co-operation and Development countries (3 percent) (Bowman 2013; Hughes and others 2012; Kushner, Groen, and Kingham 2010). At least one study suggests that the higher the surgical capacity, the lower the observed proportion of cesarean section, indicating that improved skills, materials, and capacity allow the

Table 16.1 Average National Rate of Surgery for Countries by Category of Health Expenditure, and Total Surgical Volume by Category, 2004

	Mean estimated surgical rate per 100,000 population (standard errors in parentheses)	Estimated volume of surgery in millions (%; 95% confidence interval)	Share of global population (%)
Expenditure			
Poor-expenditure countries (N = 47)	295 (53)	8.1 (3.5; 3.4–12.8)	34.8
Low-expenditure countries (N = 60)	2,255 (342)	53.8 (23.0; 9.8–97.4)	35.0
Middle-expenditure countries (N = 47)	4,248 (524)	34.3 (14.6; 23.6–43.3)	14.6
High-expenditure countries (N = 38)	11,110 (1,300)	138.0 (58.9; 132.5–143.9)	15.6
Overall			
Total global volume of surgery	n.a.	234.2 (187.2–281.2)	n.a.
Average surgical rate	4,016 (431)	n.a.	n.a.

Source: Weiser and others 2008.
Note: Expenditures are adjusted to 2004 U.S. dollars. Poor-expenditure countries = per capita total expenditure on health US$100 or less; low-expenditure countries = US$101 to US$400; middle-expenditure countries = US$401 to US$1,000; high-expenditure countries > US$1,000. n.a. = not applicable.
$p < 0.0001$ for difference between expenditure groups.

provision of a more comprehensive range of surgical services (Petroze, Mehtsun, and others 2012).

The WHO has identified a set of emergency and essential surgical interventions that all first-level hospitals with surgical capacity should be able to perform. Besides cesarean section, these procedures encompass uterine evacuation, circumcision, wound care, chest drainage, basic laparotomy, amputation, hernia repair, tubal ligation, closed or temporary reduction of fractures, cataract surgery, removal of foreign bodies, and emergency airway management and ventilation. This guideline for essential surgical services is based on the typical capacity of health facilities in remote, resource-constrained settings. These conditions involve relatively straightforward interventions, requiring less complex skills, resources, and postoperative management. Surgical providers at first-level hospitals appear to refer patients to higher-level facilities due to lack of training and experience rather than lack of resources (Bowman and others 2013; Petroze, Nzayisenga, and others 2012). The WHO recommends that referral facilities ensure capacity to provide facial and intracranial surgery, complex bowel surgery, pediatric and neonatal surgery, thoracic surgery, major ophthalmic surgery, and complex gynecologic surgery (WHO 2009c).

MORTALITY FOLLOWING SURGERY IN LMICs

As explained in chapter 2, increasing basic surgical capacity at first-level hospitals could potentially avert loss of 77.2 million disability-adjusted life years every year. However, improvements in appropriateness, safety, and quality must accompany any increase in surgical volume in LMICs to minimize harm and secure patient trust in care. Currently, resource-poor settings place little emphasis on safety or quality, effectively constraining the value of improving access to surgical care. Earlier chapters of this volume focus on the lack of services and the unmet need for surgical care; this chapter assesses the magnitude of harm from surgical interventions under these circumstances and evaluates strategies to mitigate it.

The analysis was performed in three phases. We first evaluated the unmet surgical volume using data previously gathered for a study assessing the global volume of surgery (Weiser and others 2008). We then sought to estimate potential excess harm by ascertaining postsurgical mortality rates for three procedures common in LMICs: cesarean section, appendectomy, and inguinal hernia repair. Finally, we combined these two analyses to estimate the theoretical risks if surgical capacity were increased to meet minimum estimates of delivery without concurrent improvements in mortality rates. By quantifying excess mortality across countries and settings, we demonstrate large gaps in safety and the impact these have on outcomes and postoperative mortality.

Methodology

Estimates of Minimum Surgical Rates. Using previously estimated national surgical rates for 192 countries (Weiser and others 2008), we performed an incremental surgical effectiveness analysis comparing surgical rates with average life expectancy (Goldie 2003). We eliminated "strongly dominated" nations—those that either provided more operations for equal or lesser life expectancy or provided the same amount as a nation with greater life expectancy—and then arrayed the remaining nations in ascending order by surgical rate. Incremental surgical rates and life expectancy, and the incremental surgical system effectiveness ratio were then calculated by comparing the surgical rates and life expectancy of each country with the one above it. Countries whose surgical system effectiveness ratio was greater than an adjacent, higher-rate country (that is, one in which the incremental gain in life expectancy per increase in surgery was less than its comparator) was considered "weakly dominated" and was discarded, leaving only countries with maximally "efficient" systems, that is, those with the lowest surgical rate for the highest life expectancy (table 16.2). We estimated the minimum per capita surgical rates from an "efficiency frontier" line plotted from these countries (figure 16.2).

We then created a regression model for these maximally efficient countries and extrapolated a provisional minimum surgical rate based on life expectancies of 70, 75, and 80 years. We estimated the surgical gap by determining the deficit of surgery for countries whose rates were below these minimum surgical rates at each life expectancy. Confidence intervals for the surgical deficit were calculated taking into account the error of the imputed country-specific rates.

Table 16.2 Countries with the Lowest Surgical Rates and Highest Life Expectancies Based on an Incremental Cost-Effectiveness Selection Strategy

	Life expectancy (years)	Surgical rate (per 100,000 people)
Tajikistan	63	181
Korea, Dem. People's Rep.	66	303
Panama	76	1,637
New Zealand	80	4,547
Italy	81	7,768
Japan	82	11,741

Figure 16.2 Surgical Efficiency Curve Based on Countries Whose Health Systems Provide the Lowest Surgical Rates and the Highest Life Expectancies

Note: Any particular life expectancy can be associated with a minimum estimated surgical rate based on this efficiency frontier. In this example, a life expectancy of 75 years is associated with a surgical rate of at least 1,504 per 100,000 people.

Estimates of Surgical Mortality in LMICs. We reviewed the published literature from LMICs that reported death and complication rates following three operations commonly performed in first-level hospitals: cesarean section, appendectomy, and hernia repair. Our inclusion criteria were articles published since 2000 from countries classified by the World Bank as LICs or middle-income countries in either 2005 or 2012 that reported either morbidity or mortality following one of these interventions, regardless of preoperative status, indication for intervention, or cause of death. We reviewed SCOPUS, MedLine, and PubMed, as well as other studies identified by their references or bibliographies (see annex 16A for search terms and identified references). We discarded studies that appeared to be duplicate analyses of the same data. We aggregated studies by country to create larger data samples for analysis.

Estimates of Theoretical Death Following Increased Surgical Service Delivery. We applied our estimates of surgical mortality to the volume of surgery needed to close the gap in surgical care and bring all countries falling below our minimum surgical rate up to the calculated minimum. We assumed a conservative midrange mortality rate estimate, even though we presumed that this low surgical volume continues to reflect a similar proportion of urgent cases with a correspondingly high mortality rate.

Results

Minimal Annual Surgical Rates. Six countries defined the efficiency frontier with a combination of the lowest rates of surgery and the highest life expectancies (table 16.2 and figure 16.2). Using this surgical efficiency calculation, minimum annual surgical rates observed at life expectancies of 70, 75, and 80 years were 836, 1,504, and 4,547 operations per 100,000 people, respectively. In 2004, 49 countries had rates of less than 836 per 100,000, and 65 had rates of less than 1,504 per 100,000; the vast majority of countries with rates of less than 836 were LICs. Most countries with rates higher than 4,547 per 100,000 were upper-middle-income (UMICs) or high-income countries (HICs). For LMICs to deliver at least 836 operations per 100,000 people, an additional 10.9 million operations per year (95 percent confidence interval of 3.9 million to 30.7 million) would need to be performed in these settings. To achieve a rate of 1,504 operations per 100,000 people would require an additional 28.4 million (95 percent confidence interval of 11.3 million to 71.2 million) operations annually in these countries.

Variable Mortality Rates. Based on the results of our estimates of surgical mortality, however, increased surgical capacity will exact a substantial toll in postsurgical harm and risk for adverse events. The literature search identified 131 articles that met the inclusion criteria and evaluated either mortality or morbidity from cesarean section, appendectomy, and inguinal hernia repair in LMICs. We summarize these results in tables 16.3, 16.4, and 16.5. Crude mortality rates following cesarean section ranged from 0.5 per 1,000 operations to 51.3 per 1,000. For appendectomy, the rates of death were 0 to 88.6 per 1,000 operations; and for inguinal hernia repair, rates of death ranged from 0 to 411.8 per 1,000 operations. For comparison, historical death rates following cesarean section in Sweden and the Netherlands are 0.4 and 0.53 per 1,000, respectively (Hogberg 1989; Schuitemaker and others 1997); for appendectomy they are 2.4 and 3.0 per 1,000 (Blomqvist and others 2001; Noordzij and others 2010). The mortality rate for elective inguinal hernia repair in Sweden is 1.1 per 1,000, but the rate rises to 29.5 for emergency operations; overall mortality following inguinal hernia repair is 2.4 per 1,000 in Sweden (Nilsson and others 2007). The death rate following elective inguinal hernia repair in Denmark is calculated to be 2.2 per 1,000; however, for urgent cases it is substantially higher at 70.1, with an overall mortality rate of 5.2 per 1,000 operations (Bay-Nielsen and others 2001).

Table 16.3 Published Mortality and Morbidity Rates in Selected Countries Following Cesarean Section

Country	Cesarean section rate (percent)	Total number of cesarean sections	Total number of deaths	Total number of complications	Crude mortality per 1,000 cesarean sections	Crude morbidity per 1,000 cesarean sections
Afghanistan	1.0	565	29	—	51.3	—
Brazil	45.9	371,981	202	—	0.5	—
Burkina Faso	0.7	15,279	58	206	3.8	56.0
Chad	0.4	275	11	—	40.0	—
Ethiopia	1.0	267	2	20	7.5	88.9
India	8.5	8,893	25	35	2.8	18.7
Malawi	3.1	10,201	108	151	10.6	70.9
Morocco	5.4	3231	9	165	2.8	51.1
Nigeria	1.8	4215	41	11	9.7	67.1
Pakistan[a]	7.3	14,257	39	—	2.7	—
Rwanda	2.9	896	9	—	10.0	—
Senegal	3.3	370	7	—	18.9	—
South Africa	20.6	904	1	—	1.1	—
Tanzania	3.2	6,765	7	—	1.0	—
Thailand	17.4	187	0	7	0	37.4
Uganda	3.1	500	7	77	14.0	154.0
Zimbabwe	4.8	3,147	25	—	7.9	—

table continues next page

Table 16.3 Published Mortality and Morbidity Rates in Selected Countries Following Cesarean Section (continued)

Country	Cesarean section rate (percent)	Total number of cesarean sections	Total number of deaths	Total number of complications	Crude mortality per 1,000 cesarean sections	Crude morbidity per 1,000 cesarean sections
Bangladesh, China, Indonesia, Mongolia, Myanmar, Nepal, Thailand, Sri Lanka, and Vietnam	0.4	7,390	14	1,137	1.9	153.9
Cambodia, China, India, Japan, Nepal, Philippines, Sri Lanka, Thailand, and Vietnam	0.3	29,428	35	2,895	1.2	98.4
Congo, Dem. Rep.; Burundi; and Sierra Leone	—	1,276	7	93	5.5	72.9
Côte d'Ivoire, Mali, Niger, Mauritania, Burkina Faso, and Senegal	—	335	13	—	38.8	—
Senegal and Mali	0.1	11,255	157	536	13.9	47.6
Argentina, Brazil, Cuba, Ecuador, Nicaragua, Mexico, Paraguay, and Peru	0.3	31,803	16	984	0.5	30.9

Source: Authors' calculations based on Abbassi and others 2000; Bano and others 2011; Basak and others 2011; Bouvier-Colle and others 2001; Briand and others 2012; Chilopora and others 2007; Chongsuvivatwong and others 2010; Chu and others 2012; Fauveau 2007; Fenton and others 2003; Fesseha and others 2011; Glenshaw and Madzimbamuto 2005; Imbert and others 2003; Kaboro and others 2012; Kambo and others 2002; Kandasamy and others 2009; Kelly and others 2010; Kilsztajn and others 2007; Kim and others 2012; Kor-Anantakul and others 2008; Lumbiganon and others 2010; Ministère de la Santé Burkina Faso 2013; Okafor and Okezie 2005; Okafor and others 2009; Okezie and others 2007; Oladapo and others 2007; Ozumba and Anya 2002; Rahlenbeck and Hakizimana 2002; Rutgers and van Eygen 2008; Seal and others 2010; Sekirime and Lule 2008; Sorbye and others 2011; Tshibangu and others 2002; and Villar and others 2007. Cesarean section rates for Afghanistan and The Gambia are from Kim and others 2012 and Fauveau 2007, respectively. All other cesarean section rates are from Gibbons and others 2010.
Note: Denominators of mortality and morbidity may differ due to different studies from the same country using separate patient populations. — = not available.
a. Total number of cesarean sections in Pakistan obtained from Naheed Bano, Rawalpindi Medical College, and Holy Family Hospital, Rawalpindi, Pakistan.

Table 16.4 Published Mortality and Morbidity Rates in Selected Countries Following Appendectomy

Country	Total number of appendectomies	Total number of deaths	Total number of complications	Crude mortality per 1,000 appendectomies	Crude morbidity per 1,000 appendectomies
Bangladesh	30	0	7	0	233.3
Bolivia	55	1	4	18.2	72.7
Burkina Faso	789	0	—	0	—
Cameroon	323	2	33	6.2	102.2
Central African Republic	158	14	19	88.6	188.1
China	1,269	3	143	2.4	112.7
Congo, Rep.	56	1	4	17.9	71.4
Ethiopia	200	8	64	40.0	320.0
Ghana	789	13	114	16.5	178.7
India	749	0	39	0	52.1
Iran, Islamic Rep.	450	0	17	0	37.8
Kenya	301	0	43	0	142.9
Nepal	536	3	38	5.6	102.2
Nigeria	2,220	14	492	6.3	222.8
Pakistan	516	1	58	1.9	112.4
Peru	104	0	23	0	221.2

table continues next page

Table 16.4 Published Mortality and Morbidity Rates in Selected Countries Following Appendectomy (continued)

Country	Total number of appendectomies	Total number of deaths	Total number of complications	Crude mortality per 1,000 appendectomies	Crude morbidity per 1,000 appendectomies
Senegal	100	0	—	0	—
South Africa	960	12	96	12.5	183.2
Thailand	2,139	0	26	0	12.2
Turkey	183	10	36	54.6	235.0

Source: Authors' calculations, based on Abantanga and others 2009; Adisa and others 2012; Ali and Aliyu 2012; Asefa 2002; Ayoade and others 2006; Batajoo and Hazra 2012; Chamisa 2009; Chavda and others 2005; Chung and others 2000; Cunnigaiper and others 2010; Ekenze and others 2010; Fahim and Shirjeel 2005; Farthouat and others 2005; Fashina and others 2009; Gavilan-Yodu 2010; Gurleyik and Gurleyik 2003; Ibis and others 2010; Kargar and others 2011; Kasatpibal and others 2006; Khalil and others 2011; Khan and others 2012; Khiria and others 2011; Kong and others 2012; Kumar and Jain 2004; Liu and others 2007; Mabiala-Babela and others 2006; Malik and others 2009; Mehrabi Bahar and others 2010; Ming and others 2009; Ministère de la Santé Burkina Faso 2013; Ngowe Ngowe and others 2008; Ohene-Yeboah and Togbe 2006; Okafor and others 2003; Osifo and Ogiemwonyi 2009; Paudel and others 2003; Peralta Vargas and others 2004; Pokharel and others 2011; Rogers and others 2008; Saha and others 2010; Salahuddin and others 2012; Séréngbé and others 2002; Shaikh and others 2009; Terzi and others 2010; Utpal 2005; Willmore and Hill 2001; H. S. Wu and others 2011; S. C. Wu and others 2011; and Zoguereh and others 2001. See annex 16A for a list of citations by country.
Note: Denominators of mortality and morbidity may differ due to multiple different studies from the same country using separate patient populations.
— = not available.

LICs and lower-middle-income countries have rates of death that are orders of magnitude greater than those of HICs and UMICs. Compared with Sweden, a country with historically low death rates following these three operations, cesarean section mortality is at least 2 to 4 times higher in Latin America and the Caribbean, 6 to 10 times higher in South Asia, and 100 times higher in Sub-Saharan Africa. The ranges of mortality rates following both appendectomy and inguinal hernia repair are much narrower, but there is frequently a 40-fold mortality increase in Sub-Saharan Africa, and in some cases more than a 100-fold increased risk of death for the same intervention. If LICs and lower-middle-income countries closed the gap in surgical rates to attain a minimum rate of 836 operations per 100,000 people, but surgical mortality remained at 4 percent—a number well within the range of that in Europe—436,000 people would die annually following surgery in these settings. With rates of surgery reaching 1,504 per 100,000 people in LICs and lower-middle-income countries, a postoperative mortality rate of 4 percent would increase this number to 1.14 million deaths per year. Reducing variability in mortality and bringing postoperative mortality to 1.5 percent would prevent more than 200,000 and 700,000 deaths, respectively, for these two surgical rates.

Although these estimates do not control for comorbidities or other demographic, patient, or facility factors, they suggest tremendous excess mortality following surgical interventions. The excessively high death rates following essential surgical interventions such as cesarean section, appendectomy, and hernia repair indicate that safety concerns are justified and demand attention. The variability in mortality in HICs in Europe and North America has been well established, both among and within countries; it is not surprising that this variability is more pronounced in LICs and lower-middle-income countries. However, the extreme rates of death and disability are so dramatic that health systems in these settings need to adopt strategies to improve survival and reduce complications if surgical interventions are to be acceptable and have a meaningful health impact.

CHALLENGES TO SURGICAL SERVICES IN LICs AND LMICs

The causes of the disparities in mortality described in the previous section are multifactorial and include access to care, transportation options, behaviors, and attitudes. Financial barriers in particular are substantial, especially for the poor and near poor. Catastrophic health expenditure is a major cause of impoverishment, and surgical care can quickly deplete a family's financial resources (Kruk, Goldmann, and Galea 2009; Nguyen and others 2013; Van Minh and others 2013; Xu and others 2007). Geographic and transportation barriers present a challenge for populations who live at distances from health centers and first-level hospitals. Delays in care-seeking behaviors are exacerbated when populations lack knowledge of health risks or when poor care has led to severe mistrust in health systems (Gauthier and Wane 2011; Kahabuka and others 2011; Kruk and others 2009; Yaffee and others 2012).

These factors pose difficult challenges when evaluating outcomes of surgical care. Delays in presentation for care translate into higher morbidity and mortality, particularly for surgically treatable conditions. Patients may arrive septic, malnourished, physiologically stressed, dehydrated, and anemic; many may arrive moribund. Yet those with life- or limb-threatening conditions tend

Table 16.5 Published Mortality and Morbidity Rates in LMICs Following Inguinal Hernia Repair

Country	Total number of patients undergoing hernia repair	Total number of deaths	Total number of complications	Crude mortality per 1,000 hernia repairs	Crude morbidity per 1,000 hernia repairs
Burkina Faso	7,421	36	0	4.9	0
Cameroon and Mali	524	0	5	0	9.5
China	4,072	0	13	0	3.2
Colombia	13	0	0	0	0
Côte d'Ivoire	128	1	1	7.8	7.8
Dominican Republic	239	0	0	0	0
Ecuador	102	0	0	0	0
Ghana	973	9	29	9.2	33.1
Haiti	17	0	1	0	58.8
India	358	0	31	0	86.6
Jamaica	314	0	—	0	—
Nepal	61	0	5	0	82.0
Nicaragua	10	0	0	0	0
Niger	34	14	16	411.8	470.6
Nigeria	5,451	26	275	4.8	50.5
Pakistan	605	8	25	13.2	41.3
Sierra Leone	45	5	—	111.1	—
Sudan	64	4	7	62.5	109.4
Tanzania	452	44	24	97.3	53.1
Thailand	24	0	1	0	41.7
Tunisia	595	4	—	6.7	—
Turkey	970	11	31	11.3	37.7

Source: Authors' calculations; based on Abantanga 2003; Aderounmu and others 2008; Adesunkanmi and others 2000; Akcakaya and others 2000; Akinci and others 2010; Ameh 2002; Awojobi and Ayantunde 2004; Chauhan and others 2007; Cingi and others 2005; Clarke and others 2009; Diarra and others 2001; ElRashied and others 2007; Freudenberg and others 2006; Gao and others 2009; Gil and others 2012; Harouna and others 2001; Huang and others 2005; Jani 2005; Kingsnorth and others 2006; Lagoo and others 2012; Lau and others 2002; Lohsiriwat and others 2007; Mabula and Chalya 2012; Malik and others 2010; Mbah 2007; McConkey 2002; Memon and others 2013; Ministère de la Santé Burkina Faso 2013; Mungadi 2005; Obalum and others 2008; Ohene-Yeboah 2003; Osifo and Irowa 2008; Pradhan and others 2011; Ramyil and others 2000; Samaali and others 2012; Sanders and Kingsnorth 2007; Scarlett and others 2007; Shaikh and others 2012; Shi and others 2010; Shillcutt and others 2010; Shillcutt and others 2013; Taqvi and others 2006; Turaga and others 2006; Usang and others 2008; Walk and others 2012; Wu and others 2008; Yeung and others 2002; and Zhou 2013. See annex 16A for a list of citations by country.
Note: Denominators of mortality and morbidity may differ due to multiple different studies from the same country using separate patient populations.
— = not available.

to derive the greatest benefit from interventions, but at a cost of poorer overall outcomes. The physiologic insults of surgery and anesthesia are substantial, and patients that arrive with only minimal physiological reserves fare poorly. Thus, even situations that might be considered low risk from a population perspective—such as cesarean section in otherwise young, healthy women or appendectomy in healthy young children—demonstrate high levels of complications and mortality compared with similar conditions in HICs. When addressing issues of harm from surgery, providing constructive improvement strategies to health systems and providers who work under less-than-ideal circumstances and operate on patients with more severe, life-threatening comorbid conditions are important.

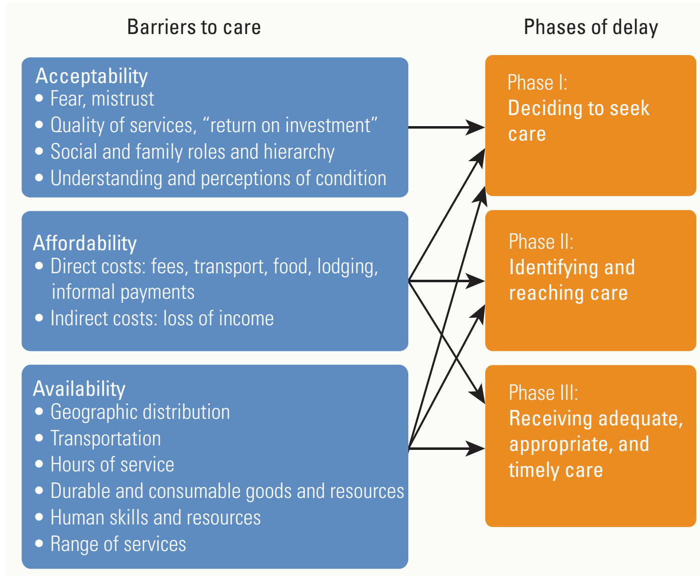
As demonstrated throughout this volume, LMICs do not meet the basic surgical needs of their populations. Estimating minimum surgical rates using a surgical rate efficiency methodology indicates that most LMICs fall far short of minimum need. In addition, death rates following common operations are substantial and exceed what would be considered acceptable in HICs. If health systems in LMICs improve their surgical numbers without concurrently improving the safety, quality, and transparency of their services, they jeopardize the health of patients seeking care and risk exacerbating mistrust.

Barriers to Surgical Care

Multiple factors contribute to the risks that surgical patients face in resource-constrained environments. Patients, particularly those whose conditions require urgent surgical interventions, encounter significant barriers to effective and timely care. These conditions can rapidly become fatal, and delays in care are associated with significantly worse outcomes. Emergency surgery carries an added risk of mortality due to the extenuating circumstances of the condition, the inability to adequately plan or prepare for the procedure, the inability to control or modify patient-specific risk factors, the logistical difficulties rallying appropriate human or infrastructure resources, and the challenge of intervening with incomplete information. Accordingly, outcomes are worse for emergency interventions compared with elective or semielective procedures. Emergency operations constitute a higher proportion of operations in resource-limited settings, and any barrier that delays presentation imposes a tremendous burden on patients and the health system.

Delays in care have been categorized into three phases: delays in deciding to seek care; delays in reaching adequate health facilities; and delays in receiving adequate, appropriate, and timely care (Thaddeus and Maine 1994). Because access to and delivery of surgical care presents particular challenges in LICs and LMICs, it is especially important to understand the barriers that contribute to delays in definitive interventional care. These barriers can generally be divided into three dimensions: availability, affordability, and acceptability (Grimes and others 2011; McIntyre, Thiede, and Birch 2009). Each of these dimensions causes delays experienced by patients in need of surgical care (figure 16.3).

Figure 16.3 Relationship of Barriers to Care and Delays in Obtaining Care



Source: Adapted from Thaddeus and Maine 1994.

Availability of Care. *Availability* refers to the following:

- The relationship between the location of health care facilities with the capacity to provide appropriate services, the location of the population needing them, and the transport opportunities available
- The ability and willingness of care providers to serve the population in accordance with the type and severity of the presenting condition
- The timing and hours of available services and the times patients seek care
- The range, quantity, and quality of services provided and the nature and extent of the health needs of people seeking care

A tremendous obstacle to early presentation is the geographic distribution of health facilities with the capacity to recognize and deal with surgical issues (Dye and others 2010; Hang and Byass 2009; Macharia and others 2009; Mock, nii-Amon-Kotei, and Maier 1997; Parkhurst, Rahman, and Ssengooba 2006). Health centers with the sophistication to provide surgical care tend to be located in more populous areas, and LMICs with the lowest surgical volumes frequently have large rural populations. Timely transport to surgical care is critical, yet road and transportation infrastructure can be lacking or intermittent (Macharia and others 2009; Mock, nii-Amon-Kotei, and Maier 1997; Seljeskog, Sundby, and Chimango 2006). Finally, social norms can prevent early presentation; consultation with traditional healers, village elders, or heads of family may delay access to the formal health care system (Briesen and others 2010; Hang and Byass 2009; Mock, nii-Amon-Kotei, and Maier 1997; Parkhurst, Rahman, and Ssengooba 2006; Seljeskog, Sundby, and Chimango 2006).

Once patients do arrive at facilities, the requisite durable and consumable supplies and equipment are often inadequate (Lebrun, Chackungal, and others 2013; Lebrun, Dhar, and others 2014; Macharia and others 2009). The availability of personnel and services is often intermittent, particularly at night. Above all, the human resources for health are frequently lacking. Surgical skill requires education, training, and experience; trained clinicians are not always available or capable of performing specific surgical tasks; the status of anesthesia services, as discussed in chapter 15, is even more dire. Providers' confidence in their skills is particularly important for the provision of surgical care; recent research has indicated that lack of confidence—due to lack of training, experience, or surgical assistance—may be a primary cause of triage and transfer, as well as a major barrier preventing immediate intervention (Bowman and others 2013; Petroze, Nzayisenga, and others 2012).

Affordability of Care. *Affordability*, the match between costs of services and the ability of individuals to pay, presents a major challenge because of the following factors:

- Price of services at the point of delivery
- Direct costs associated with transportation, food, and lodging
- Indirect costs, such as lost income or productivity

The ability of individuals to pay also relates to their personal wealth and assets, eligibility for financial support from financing mechanisms, and amount of indirect costs incurred. Transportation costs can be unaffordable, and, when combined with prohibitive out-of-pocket expenses, frequently delays early consultation (Afsana 2004; Mock, nii-Amon-Kotei, and Maier 1997; Nwameme, Phillips, and Adongo 2013). In addition, affordability refers not just to the ability of an individual or family to pay for care but also the potential impact of that payment on the household, and the manner and timing of payment. For example, up-front charges may prevent early assessment and definitive management as families seek to secure necessary funds for payment for services (Kruk, Goldmann, and Galea 2009).

Acceptability of Care. *Acceptability* refers to the expectations, behaviors, perceptions, and attitudes inherent in medical encounters. Providers' attitudes are affected by stereotypes, chief complaints, and the manner of presentation. Patients' attitudes are similarly affected by stereotypes, as well as by perceptions of respect, efficiency of care, and trust in the integrity of the system. Of particular concern with surgical intervention is the personal security of clinicians; deaths following surgery may be blamed directly on surgical providers, and family and community members may seek retribution, regardless of premorbid conditions or cause of demise (Burch and others 2011; Malik and others 2010).

Many of these domains interact in ways that magnify delays. Concerns about financial commitments, compounded by mistrust of the health care system, a lack of transparency, and poor quality, lead to long delays in treatment-seeking behavior. People in many LMICs may justifiably perceive surgical care to be a poor investment of resources.

Anesthesia Safety

The safe provision of anesthesia is a critical consideration in establishing and expanding the capacity for surgical care. Improvements in anesthetic monitoring and techniques have led to dramatic improvements in its safety profile in HICs and UMICs. In many settings with low levels of human resources, however, anesthesia is provided by nonphysician clinicians or technicians, or even by the operating surgeons. Poor training, supervision, and monitoring standards all contribute to high mortality from the administration of anesthesia.

Although the rate of overall deaths due to anesthesia is estimated to be 34 per 1 million anesthetics administered, profound differences exist among countries and settings. Bainbridge and others (2012) report that in low human development index countries, deaths solely attributable to anesthesia are estimated to be 141 per million, compared with 25 per million in high human development index countries. Critically, anesthesia mortality in LMICs continues to be a major problem, with death rates as high as one per 500 (Walker and Wilson 2008). Anesthesia in HICs and UMICs has improved only relatively recently, with changes in monitoring and increased standardization responsible for a 100-fold reduction in mortality over the past 40 years—34 deaths per million instances of anesthetics administered in the 1990s and 2000s, down from 357 deaths per million before 1970 (figure 16.4). Low professional standing, inadequate basic monitoring equipment, and a lack of professional standards all contribute to the current disparity between HICs and other countries.

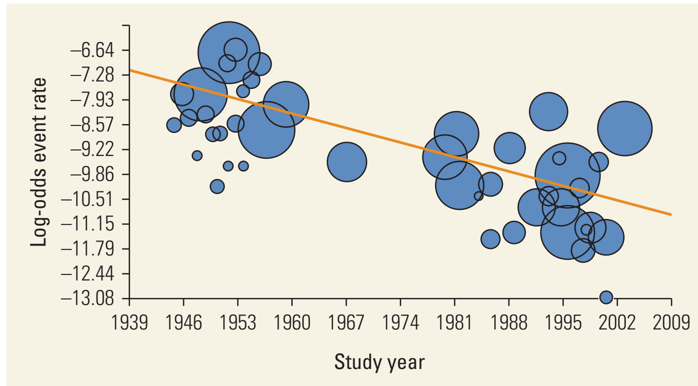
Perioperative Safety

Surgical intervention, by its nature, involves risks. High-quality and high-resource systems still fail to provide proven interventions every time for every patient.

In the United States, the failure to adhere to basic WHO standards occurs in 6 percent to 20 percent of operations, indicating substantial room for improvement (Stulberg and others 2010). Individual care standards are being used in pay-for-performance initiatives to help improve quality by linking it to reimbursement. When individual standards are evaluated in isolation, however, they frequently fail to demonstrate improvements in outcomes with improving levels of compliance (table 16.6) (Stulberg and others 2010). Multiple care standards need to be evaluated as a composite whole; partial completion of tasks does not always deliver a partial benefit, and improvements often require total compliance to result in improved outcomes (Nolan and Berwick 2006).

This all-or-none compliance likely indicates that systems able to achieve high compliance rates with multiple standards-of-care processes are highly organized and functioning efficiently; accordingly, they are able to deliver on difficult-to-measure but essential components of care, such as communication and information transfer (Weiser 2010). In LMICs, lack of compliance may be especially germane—poorly used or misallocated

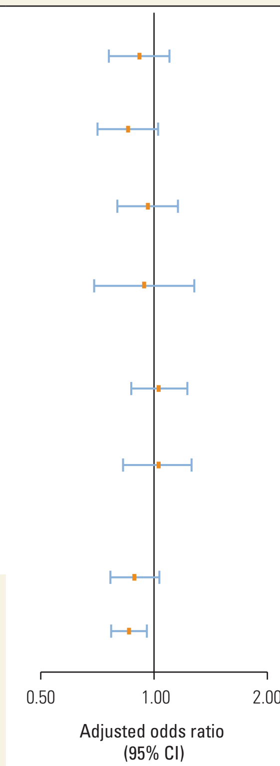
Figure 16.4 Meta-Regression for Risk of Death due Solely to Anesthesia, 1939–2009



Source: Bainbridge and others 2012.
Note: Every circle represents a study; the circle size is representative of the weight of that study in the analysis. The relationship between mortality and year of study was significant, with a significant decline over the decades (slope −0.053; 95 percent confidence interval of −0.058 to −0.049; $p = 0.000001$).

Table 16.6 Surgical Care Improvement Project: Infection-Prevention Process Measures

	Nonadherent discharges		Adherent discharges		
	Postoperative infections	Discharges	Postoperative infections	Discharges	Adjusted odds ratio (95% CI)
Individual SCIP measures					
Prophylactic antibiotic received within 1 hour prior to surgical incision	251	18,147	1,394	190,925	0.89 (0.75–1.06)
Prophylactic antibiotic selection for surgical patients	266	12,670	1,486	198,002	0.83 (0.69–1.00)
Prophylactic antibiotics discontinued within 24 hours after surgery end time	310	26,499	1,024	173,228	0.94 (0.78–1.13)
Cardiac surgery patients with controlled postoperative morning blood glucose	65	4,168	362	31,512	0.93 (0.68–1.27)
Surgery patients with appropriate hair removal	194	21,308	3,539	360,111	1.00 (0.85–1.19)
Colorectal surgery patients with immediate postoperative normothermia	181	4,564	676	18,101	1.00 (0.81–1.23)
Composite measures					
SCIP Antibiotic Measures (1st three above) performed	511	44,417	816	154,963	0.86 (0.74–1.01)
At least 2 of the above SCIP measures recorded in a single visit	843	59,356	1,070	158,304	0.85 (0.76–0.95)

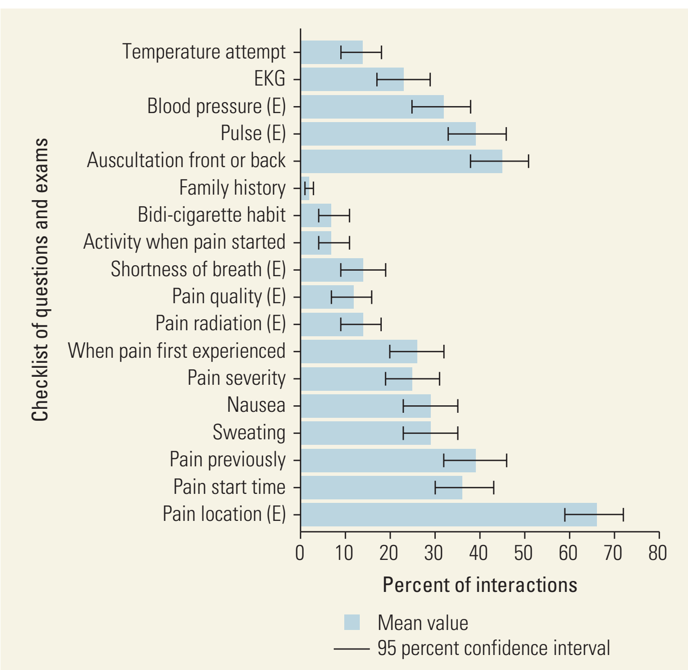


Source: Stulberg and others 2010.
Note: Each estimate accounts for the surgical procedure performed, patient characteristics, and hospital characteristics. CI = confidence interval; SCIP = Surgical Care Improvement Project.

resources constitute a drain on an already stressed health system.

Compliance with care standards in LMICs is frequently poor. In a study in India, Das and others (2012) selected a random sample of health care providers in rural Madhya Pradesh and urban Delhi to receive a visit from a "standardized patient" trained to present one of three scenarios: unstable angina, asthma, or a parent describing dysentery in a child at home. These standardized patients were then debriefed following their clinic visit to assess the quality of care and compliance with care checklists and best practices. Providers in both locations did poorly in asking appropriate questions and performing appropriate examinations (33.7 percent and 31.8 percent in Madhya Pradesh and Delhi, respectively); making the correct diagnosis (12.2 percent and 21.8 percent in Madhya Pradesh and Delhi, respectively); and identifying pertinent clinical issues and making appropriate recommendations for treatment (30.4 percent and 45.6 percent in Madhya Pradesh and Delhi, respectively) (figure 16.5). The rate of unnecessary or harmful treatments exceeded 40 percent in Madhya Pradesh. Despite the range of provider education, from no formal medical education to fully licensed physician, only a small difference was observed in adherence to care standards; no difference was observed in arriving at the correct diagnosis or providing the correct treatment.

Figure 16.5 Adherence to Checklist of Questions and Examinations for Unstable Angina, Madhya Pradesh, 2010



Source: Das and others 2012.
Note: All items listed are recommended; those marked (E) are essential. "Temperature attempt" refers to checking temperature either by touch or with a thermometer. EKG = electrocardiogram and refers to either an electrocardiogram performed by practitioners or referrals for electrocardiograms. "Bidi-cigarette habit" indicates whether the doctor asked about tobacco use; a bidi is an Indian cigarette consisting of tobacco wrapped in a leaf. "Pain start time" is asked to ascertain a specific time of day.

Such studies point to troubling discrepancies between what is known and taught about care standards, on the one hand, and actual practice patterns, on the other hand. Adherence to known practice standards is a hallmark of high-quality health organizations; yet, similar to what is found in primary care and general practice settings, surgical delivery in HICs and LMICs alike frequently fails to follow standards of care, despite well-described strategies and techniques for improvement.

Postoperative Care and Safety

In addition to the risks during surgery, patients are at high risk during postoperative recovery. The two most common causes of complications within the first week of surgery are bleeding and infections. Additional causes of delayed morbidities include blood clots, heart attacks, pneumonia, and stroke. Anticipating potential complications, and either preventing them (for example, by prophylaxis for venous thromboembolism) or identifying the signs and symptoms and intervening early and aggressively, are essential to reduce these risks.

An important study established the prominent role of a mature system of postoperative care in managing complications and preventing them from resulting in death (also known as *failure to rescue*). Ghaferi, Birkmeyer, and Dimick (2009a, 2009b) found that although baseline complications rates were strikingly similar in institutions across the United States, mortality rates following these complications varied dramatically (figure 16.6 and table 16.7). These findings confirm earlier research suggesting that the primary difference in outcomes among hospitals is not due to differences in complication rates but to differences in the rates of failure to rescue (Silber and others 1992).

Further research has demonstrated that higher-volume hospitals appear to have a better ability to recognize, intervene, and save patients undergoing high-risk procedures from death and complications following surgery (Ghaferi, Birkmeyer, and Dimick 2011). Complications must be anticipated following high-risk procedures; the ability to recognize, diagnose, and treat complications separates the high performers from the poor performers. The quality of communication and the systems of care, and the skills and capacity of ancillary services—such as availability of intensive care and the presence and experience of specialized services—appear to be important factors for improving outcomes following complications.

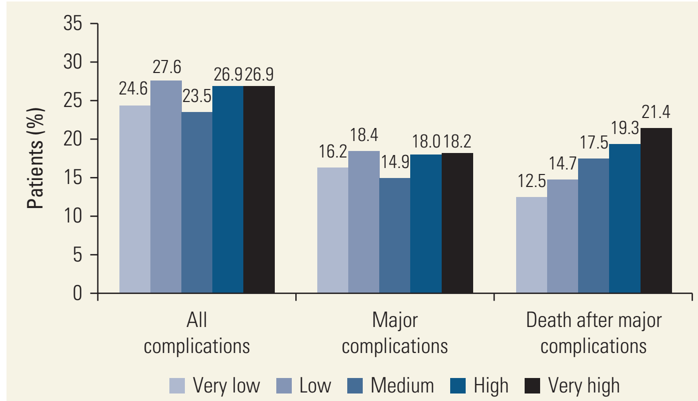
STRATEGIES FOR IMPROVING SURGICAL CARE

Several effective strategies have been identified for improving surgical outcomes in LMICs. These strategies include the adoption and use of basic technologies, the development of monitoring standards, and the use of surgical safety checklists. Organizational and management strategies also appear to be important. Essential to all of these interventions is a mandate to measure the delivery of care and its impact on health. These low-cost interventions, which can dramatically lower postsurgical mortality rates, demand prioritization by health systems seeking to improve access and surgical service provision.

Anesthetic Monitoring and Safety

One of the most important contributions to improved surgical safety has been the development of basic standards of anesthetic monitoring. The Harvard monitoring

Figure 16.6 Rates of All Postsurgical Complications, Major Complications, and Deaths after Major Complications, According to Hospital Quintile of Mortality



Source: Ghaferi and others 2009b.
Note: Although rates of all complications and major complications did not vary significantly across hospital mortality quintiles, the rate of death in patients with major complications was almost twice as high in hospitals with very high overall mortality as in those with very low overall mortality (21.4 percent versus 12.5 percent, $p < 0.001$).

Table 16.7 Rates of Deaths, Complications, and Death after Major Complications for Five Operations with the Highest Number of Deaths, According to Hospital Quintile of Mortality, 2005–07

Type of surgery	Very low mortality (percent of patients)	Very high mortality (percent of patients)	Odds ratio for very high versus very low mortality (95% confidence interval)
Colectomy			
Overall mortality	2.5	5.6	2.29 (1.76–2.98)
All complications	24.7	28.1	1.19 (0.95–1.50)
Major complications	15.4	17.6	1.17 (0.94–1.46)
Mortality after major complications	11.4	20.5	2.08 (1.54–2.82)
Abdominal-aortic-aneurysm repair			
Overall mortality	3.1	7.3	2.49 (1.63–3.81)
All complications	17.4	19.3	1.13 (0.87–1.46)
Major complications	13.6	15.5	1.26 (0.86–1.56)
Mortality after major complications	15.6	26.3	1.94 (1.04–3.62)
Above-knee amputation			
Overall mortality	10.0	15.0	1.59 (1.00–2.53)
All complications	25.7	26.6	1.05 (0.75–1.47)
Major complications	18.9	18.6	0.98 (0.67–1.43)
Mortality after major complications	20.8	35.2	2.08 (0.94–4.60)
Lower-extremity bypass			
Overall mortality	1.9	2.9	1.55 (0.92–2.60)
All complications	24.0	23.6	0.97 (0.81–1.17)
Major complications	11.5	11.1	0.95 (0.75–1.22)
Mortality after major complications	8.2	12.7	1.63 (0.76–3.53)

table continues next page

Table 16.7 Rates of Deaths, Complications, and Death after Major Complications for Five Operations with the Highest Number of Deaths, According to Hospital Quintile of Mortality, 2005–07 (continued)

Type of surgery	Very low mortality (percent of patients)	Very high mortality (percent of patients)	Odds ratio for very high versus very low mortality (95% confidence interval)
Below-knee amputation			
Overall mortality	4.2	8.4	2.07 (1.18–3.63)
All complications	23.7	25.4	1.09 (0.82–1.46)
Major complications	15.5	17.3	1.14 (0.81–1.60)
Mortality after major complications	14.5	29.7	2.49 (1.10–5.63)

Source: Ghaferi, Birkmeyer, and Dimick 2009b.

standards for intraoperative anesthesia care formalized a set of medical standards of practice that have become de facto international standards endorsed by the World Federation of Societies of Anaesthesiologists (Eichhorn and others 1986; WFSA 2008). The standards include the continuous presence of trained anesthesia providers and the uninterrupted monitoring of oxygenation, ventilation, and perfusion. Today, adherence to these standards in HICs is essentially universal; however, this was not the case a mere three decades ago, and it is far from standard practice in many LMICs.

In addition to continuous monitoring techniques, anesthesia delivery systems have been standardized, with safety engineered into the instruments themselves. Inhalational anesthetic machines are now engineered to be redundant; safety features, such as auto-lock mechanisms, prevent lethal hypoxic gas mixtures. Despite the 100-fold plunge in anesthetic-related mortality rates in HICs and UMICs during the past 40 years, anesthetic mortality in LMICs is a major problem due to lack of professional stature, training, and credentialing of anesthesia providers; deficiencies in basic monitoring equipment; and failure to adhere to strict standards of care.

One critical mechanism for anesthesia monitoring is the use of pulse oximetry. Although the continuous monitoring of blood oxygen levels using a pulse oximeter is considered an essential standard, more than 77,000 operating rooms worldwide do not have this basic monitoring device (Funk and others 2010). Pulse oximetry can alert anesthesia personnel to drops in oxygenation before clinical signs become apparent, allowing for corrective actions before hemodynamic instability or lethal arrhythmias occur. In Moldova, an implementation program supplying pulse oximetry equipment in conjunction with provider training on the use of a surgical safety checklist reduced postoperative deaths and complications (Kwok and others 2013). Use of pulse oximetry is highly cost-effective as well, with the cost per DALY averted from anesthetic mishaps due to improved monitoring at US$374 for a standard commercial oximeter and US$115 for a smaller hand held device (Burn and others 2014). A concerted effort is underway through the Lifebox Foundation to provide pulse oximetry monitoring capabilities to every operating theater in the world (http://www.lifebox.org).

Surgical Checklists

Standardization of care is essential because of the tremendous magnitude of interactions and care processes that occur during even simple surgical procedures. Complex patient characteristics, therapeutic options, technical demands, and team dynamics require specific strategies for organizing care protocols and service delivery. The effective use of checklists by teams during surgery has cut mortality rates by up to 50 percent.

In 2008, the WHO codified a set of basic surgical standards into guidelines for safe surgery. Researchers transformed these guidelines into a simple, 19-item checklist to be used during the perioperative period and conducted a multicenter trial assessing the efficacy of this safety tool on postoperative morbidity and mortality (figure 16.7). In a pre- and postanalysis of nearly 8,000 surgical patients, use of this checklist nearly doubled adherence to basic perioperative safety standards, including confirmation of the procedure and operative site, administration of antibiotics, use of pulse oximetry for monitoring, objective airway assessment, and completion of instrument and sponge counts at the conclusion of the operation. Use of the checklist reduced deaths by more than 47 percent and cut complication rates by 35 percent (Haynes and others 2009). This beneficial effect was maintained in a subanalysis of urgent and emergency cases (Weiser, Haynes, Dziekan, and others 2010).

Several other large, well-designed studies have confirmed the substantial enhancements to surgical safety

Figure 16.7 World Health Organization Surgical Safety Checklist

Before induction of anesthesia →

(with at least nurse and anesthetist)

Has the patient confirmed his/her identity, site, procedure, and consent?
- ☐ Yes

Is the site marked?
- ☐ Yes
- ☐ Not applicable

Is the anesthesia machine and medication check complete?
- ☐ Yes

Is the pulse oximeter on the patient and functioning?
- ☐ Yes

Does patient have a:

Known allergy?
- ☐ No
- ☐ Yes

Difficult airway or aspiration risk?
- ☐ No
- ☐ Yes, and equipment/assistance available

Risk of >500ml blood loss (7ml/kg in children)?
- ☐ No
- ☐ Yes, and two IVs/central access and fluids planned

Before skin incision →

(with nurse, anesthetist, and surgeon)

- ☐ Confirm all team members have introduced themselves by name and role.
- ☐ Confirm the patient's name, procedure, and where the incision will be made.

Has antibiotic prophylaxis been given within the last 60 minutes?
- ☐ Yes
- ☐ Not applicable

Anticipated critical events

To surgeon:
- ☐ What are the critical or nonroutine steps?
- ☐ How long will the case take?
- ☐ What is the anticipated blood loss?

To anesthetist:
- ☐ Are there any patient-specific concerns?

To nursing team:
- ☐ Has sterility (including indicator results) been confirmed?
- ☐ Are there equipment issues or any concerns?

Is essential imaging displayed?
- ☐ Yes
- ☐ Not applicable

Before patient leaves operating room

(with nurse, anesthetist, and surgeon)

Nurse verbally confirms:
- ☐ The name of the procedure
- ☐ Completion of instrument, sponge, and needle counts
- ☐ Specimen labeling (read specimen labels aloud, including patient name)
- ☐ Whether there are any equipment problems to be addressed

To surgeon, anesthetist, and nurse:
- ☐ What are the key concerns for recovery and management of this patient?

Source: WHO 2009b.
Note: This checklist is not intended to be comprehensive. Additions and modifications to fit local practice are encouraged. IV = intravenous therapy; kg = kilogram; ml = milliliter.

that checklists provide. Following the introduction of a comprehensive perioperative checklist in six hospitals in the Netherlands, postoperative complications and deaths dropped by 30 percent and 47 percent, respectively; in five control hospitals, no improvements were noted during the same period (de Vries and others 2010). A second study in the Netherlands virtually repeated the original multinational WHO investigation, demonstrating improvements in postoperative mortality that strongly correlated with checklist compliance (van Klei and others 2012).

Just as a pilot's checklist does not instruct a pilot how to fly a plane, surgical checklists do not dictate how clinicians should deliver care; instead, checklists help confirm critical steps, prompt consideration of extenuating or unusual factors, and stimulate or facilitate team communication. These processes are particularly important in the complex and multidisciplinary environment of surgery. Checklists are often a critical part of crew resource management, a method of team training that promotes shared mental models for care and conduct that has been implemented in many organizations and sectors in which high reliability and fidelity are paramount, such as aviation and nuclear power. This method has been extended to surgical teams; it has been observed, for example, that cardiac surgery teams that consistently work together are more efficient and have better outcomes than those with rotating members (Carthey, de Leval, and Reason 2001; de Leval and others 2000). Because this method is often not possible in urgent circumstances or when human resources are limited, checklists can play an essential role in promoting consistent processes of care. A study conducted at 74 Veterans Administration hospitals in the United States demonstrated significant improvements in mortality compared to controls following a full-day team training program that included implementation and training in the use of checklist-guided briefings and debriefings (Neily and others 2010).

Checklists have become an established standard of surgical care globally (Birkmeyer 2010). Their effectiveness has demonstrated the accuracy of previous estimates suggesting that at least 50 percent of existing surgical mortality is preventable. Checklists are most effective when they are implemented, not as a tickbox exercise, but as a means to reinforce communication, prompt genuine dialogue and discussion of critical information, and facilitate prospective feedback and quality improvement (Weiser, Haynes, Lashoher, and others 2010). Large-scale regulatory mandates alone appear not to be effective in fostering effective adoption (Urbach and others 2014). Implementation has been found to require local champions from all disciplines, support from leadership, monitoring of progress, and involvement of frontline clinicians (such as through team training) and not just administrators. Such an approach has been followed in Scotland, leading to a statistically significant drop in inpatient surgical death rates from 2011 after three years of flat mortality rates. The Scottish government has documented more than 9,000 lives saved (Leitch 2012).

The challenge of conducting multidisciplinary implementation programs in LMICs raises legitimate concerns about ability to scale up such programs globally. However, a follow-up WHO study in Honduras, Moldova, and Zambia confirms the ability to implement and replicate large improvements in safety and outcomes (Kim and others 2012).

Management Practices

Effective and efficient management strategies are an essential component in the smooth functioning of health facilities. Numerous econometric studies have looked at management practices in industry and business and identified characteristics that affect productivity. Two economists from Stanford University and the London School of Economics conducted a series of interviews with midlevel managers from a range of medium-sized manufacturing firms in France, Germany, the United Kingdom, and the United States, using a survey to assess four domains of management: operations, monitoring, targets, and incentives (Bloom and van Reenen 2007). High scores in these domains were strongly related to higher productivity and profitability, as well as to the longevity of the company.

In LMICs, however, multiple factors affect the performance of industry, particularly for the worse. Management practices are suboptimal for various reasons, including lack of knowledge of optimal management practices, reduced competition, high proportion of family ownership, lack of delegation of decision making because of fear or mistrust, reduced incentives, and poorly allocated financing. Bloom and van Reenen (2010) and Bloom and others (2010) note that similarly sized local firms in LMICs were severely lacking in management practices, with correspondingly lower overall productivity. Although economic environments and organizational factors played a role (Bloom, Sadun, and van Reenen 2012), introducing management practices through an intensive consulting process resulted in massive improvements in efficiency and productivity (Bloom and others 2010; Bloom and others 2013).

In health care, the management practices evaluated by Bloom and van Reenen (2010) roughly translate to operations management, quality evaluation, goal-setting, and talent management. Their scoring mechanism has been used to evaluate hospital management practices and its subsequent correlation with patient outcomes across Brazil, Europe, India, and the United States. They find tremendous variability in management practices within countries, as well as a particularly large proportion of poorly managed hospitals in LMICs. A McKinsey study looking at hospitals in the United Kingdom and the United States determined that an increase of 1 point on Bloom's management practice survey scale is associated with a decrease of 6 percent to 7 percent in 30-day mortality following acute myocardial infarction, an increase in hospital earnings of 14 percent to 33 percent, and an overall improvement in patient satisfaction (Bury and others 2007).

Although there is a paucity of research in the area of hospital management in LMICs, it is reasonable to infer that management practices affect the organizational structure, efficiency, and even safety of the health system. In one of the first studies of this kind, Funk and others (2013) suggest that more robust management practices are associated with enhanced surgical productivity. Unfortunately, many first-level rural and urban referral hospitals in LMICS are likely to be plagued by poor management practices similar to their business and manufacturing counterparts. Such problems lead to waste and poor resource allocation, and potentially even to fraud and abuse. It remains to be seen whether improvements in management translate into improved surgical productivity in these settings and, if so, the mechanisms by which such improvements occur.

One essential mechanism that management uses to enhance the quality of care is the implementation of surveillance and evaluation practices, allowing quality improvement (QI) programs to be targeted to identified weaknesses. These practices range from very simple outcome assessments, such as Morbidity and Mortality Conferences (M&M), to more complex monitoring, such as ongoing surveillance of complications, adverse events, and errors, and use of risk-adjusted mortality. Many hospitals in LMICs have some type of QI activity, even if limited to periodic M&M conferences. Often, the effectiveness of these efforts could be increased by simple measures, such as better recording of problems discussed, more purposeful enactment of corrective action, and monitoring of the outcome of the corrective action. A WHO review of the effectiveness of QI programs for trauma care identifies 36 studies, 34 of which report improvements in patient outcomes (including mortality) or process of care after a new QI program or method is introduced (Juillard and others 2009). Two articles report no change, and no articles report a worsening of any outcome; five articles also report cost savings. Most of the articles were from HICs; two were from Thailand. A summary of the model QI program in Thailand is provided in chapter 3 on trauma care in this volume. The WHO has outlined a multimodal approach to QI processes for trauma systems through the use of morbidity and mortality, preventable death panel reviews, audit filters, and the establishment of trauma data bases and surveillance systems (WHO 2009a).

Measurement Strategies

The measurement of outcomes of intervention, regardless of the service provided, is essential to ensure that the effects of care are aligned with intent and that resources are used efficiently, effectively, and with the least harm to patients. Practitioners, facilities, and health systems require information on surgical capacity, throughput, and results to determine how such service lines perform. Other notable public health successes, such as improvements in maternal and neonatal health, HIV care, and control of poliomyelitis and malaria, have been dependent on surveillance (Ceesay and others 2008; Ronsmans and Graham 2006; WHO 2000, 2005, 2007). Surveillance is equally essential in optimizing access to and the safety of surgical care; the absence of data on surgical delivery and outcomes perpetuates the neglect such therapy receives in resource-constrained settings (Weiser and others 2008, 2009).

The WHO has proposed a set of standardized metrics for surgical surveillance at the national level that have been tested and validated (WHO 2009d), and is included in annex 16B. These metrics include the number of operating rooms in each country, the numbers of trained surgeons and trained anesthetists in each country, the number of procedures performed in operating rooms in each country, the number of deaths on the day of surgery, and the number of in-hospital deaths after surgery (Weiser and others 2009) (table 16.8). Although each

Table 16.8 Standardized Statistics for Surgery: Definitions, Rationale, and Data Sources

	Definition	Rationale for use	Data sources	Comments
Number of operating rooms	Operating rooms are rooms used specifically for surgical procedures and equipped to deliver anesthesia	The number of operating rooms available to a population is a structural indicator of the ability to provide surgical interventions.	Administrative records based on reported data by inpatient and outpatient facilities; censuses of health facilities	Minor procedure rooms that are not suitable for invasive operations and are not equipped to deliver anesthesia should not be included in the total number of operating rooms.
Number of accredited surgeons and number of accredited anesthesia professionals	Accredited surgeons are physicians who have achieved certification in a surgical specialty as recognized by the accepted national standards of the state or national professional organizations. Accredited anesthesia professionals are physicians, nurses, and other practitioners who have achieved certification in the provision of anesthesia as recognized by the accepted national standards of the state or national professional organizations	The availability and composition of human resources for health is an important indicator of the strength of the health system.	Facility surveys, labor force surveys, and records from professional and administrative sources	Each country can define the acceptable national standards for accreditation of surgeons and anesthesia professionals. The word *professional* in anesthesia professional recognizes the important contribution nonphysician anesthesia practitioners provide in all countries. Individuals who perform surgery or administer anesthesia but are not accredited, including those still in training, should not be included in this measure.

table continues next page

Table 16.8 Standardized Statistics for Surgery: Definitions, Rationale, and Data Sources (continued)

	Definition	Rationale for use	Data sources	Comments
Number of surgical procedures done in an operating room per year	The absolute number of all surgical procedures, defined as the incision, excision, or manipulation of tissue that requires regional or general anesthesia, or profound sedation to control pain, undertaken in an operating room	Surgical volume is an indication of the access to and use of health care, particularly surgical services.	Hospital records and routine health service statistics	Invasive procedures that meet the definition but that are done in a procedure room not suitable for more extensive operations should not be considered in the total number of surgical procedures. If, however, they are done in the operating room, they should be counted.
Day-of-surgery death ratio	Number of deaths on the day of surgery, irrespective of cause, divided by the number of surgical procedures in a given year or period, reported as a percentage	Day-of-surgery death ratios allow the health system to assess its performance and the state of health of the population.	Administrative and hospital records based on health service statistics	Death on the day of surgery often reflects the comorbidities and physiological disorders of the patient, the quality and complexity of surgical care, or the risks of anesthesia. This measure cannot be used to compare one site, facility, or country with another without appropriate, validated, and time-consuming risk adjustment.
Postoperative in-hospital death ratio	Number of deaths in the hospital following surgery, irrespective of cause and limited to 30 days, divided by the number of surgical procedures done in a given year or period, reported as a percentage	The in-hospital death ratio after surgery provides insight into the risks associated with surgical intervention.	Administrative and hospital records based on health service statistics	Patients who undergo surgery and die outside a health facility or after readmission to the same or a different facility are important to record in postoperative mortality assessments. Facilities should be encouraged to gather such information. Neither circumstance is included in this statistic, however.

Source: Weiser and others 2009.

of these metrics has important weaknesses that must be acknowledged, all can be obtained and reported in a straightforward manner.

National-level metrics nonetheless require the interest, investment, and commitment of the central government or agency responsible for collecting, analyzing, and disseminating such information. Local efforts at QI should not be limited to crude, population-level data collected to measure health system performance. Several basic metrics must be adopted by facilities and health systems to improve the quality and delivery of care (table 16.9). These could include the following:

- *Structural metrics*, such as the availability of essential monitors like pulse oximetry; equipment, such as anesthetic machines and autoclaves; and consumable and reusable materials, such as surgical equipment, devices, and antibiotics
- *Process metrics,* such as hours of operation, duration of operations, number of operations per operating room, appropriate administration of antibiotics, and use of and compliance with checklists
- *Outcome metrics beyond mortality*, such as surgical infections and reoperation, and other perioperative complications such as pneumonia, renal failure, heart attack, or stroke

One of the issues of greatest concern is the misuse of such metrics to deny care to the most frail and vulnerable populations. Health systems that manipulate their outcomes by increasing inappropriate services, failing to intervene, and underreporting mortality succumb to perverse, negative incentives that divert essential resources and inhibit care for the sickest patients. Under ideal circumstances, surgical statistics should help health systems improve the delivery

Table 16.9 Proposed Facility-Level Metrics for Quality Improvement, in Addition to the Standardized Statistics Described in Table 16.8

Structural metrics	Process metrics	Outcome metrics
Number of pulse oximeters per operating room	Number of cases performed with pulse oximetry in place for entirety of operation	Surgical-site infection rates
Number of functional anesthetic machines	Number of cases delayed because of lack of equipment or supplies	Percentage of cases requiring reoperation
Number of functioning autoclaves	Number of cases delayed because of lack of personnel	Other complication rates, for example, transfusion or renal insufficiency
	Percentage of cases in full checklist compliance	
	Percentage of cases with appropriate antibiotic administration	
	Percentage of essential surgical procedures transferred to another facility	

and safety of surgical care by creating benchmarks for improvement rather than being used for punishment or comparison across fundamentally different organizations, environments, and populations (WHO 2009b). Attempts at comparisons across systems, countries, and health settings ignore variations in patient condition and complexity of procedure. Hospitals and health systems that wish to evaluate differences between facilities and practitioners must account for the characteristics of the patients, case mix, and urgency—all of which require robust and sophisticated data collection that is frequently beyond the capacity of overworked or underfinanced health systems. However, countries and health systems in LMICs that are able to collect such metrics will have a foundation of information upon which they can improve and sustain surgical care to the betterment of their nation's health.

Any complete discussion of quality clearly encompasses more than simple measures of mortality and complications. Important outcomes also include, among others, the nuanced measures of functional recovery, control of pain, and satisfaction with care. While meaningful, these issues are beyond the scope of this chapter, as are the potentially important strategies for improving surgical capacity through the use of physician extenders and task sharing, and the aggregation and centralization of cases to take advantage of volume-outcome relationships.

Much work is needed to strengthen surgical systems of care, and the investments are likely to be considerable. Given the barriers to access and delivery of needed surgical services, investments are necessary at the facility and institutional level, as well as for the progressive financing of health protection and communication and transportation infrastructure. Improving anesthetic monitoring and safety, implementing surgical checklists, refining management practices, and instituting measurement and surveillance techniques could dramatically improve care within existing health systems. However, designing, implementing, and scaling these interventions in LMICs will take considerable resources because each strategy for improvement requires training, infrastructure, an information management system, and political will. Even though little is currently known about the actual investment and recurrent costs of introducing and scaling up these strategies, they are likely to be highly cost-effective.

CONCLUSIONS

To avoid premature death, disability, and suffering from the time of birth through adulthood, most human beings require surgical care at some point in their lives. Strategies to increase access to surgical care, however, must also increase the safety and quality of care. Profound consequences, including massively high rates of disability and death, ensue when health systems neglect to use strategies known to improve surgical safety. Profound indirect consequences also follow that are harder to measure but that are also extremely important, including loss of confidence in the health system, late patient presentation, and cost inefficiencies that add to an overburdened and underfunded health system. Well-established interventions have proven effective in reducing surgical risk and provide promising strategies to further reduce harm from surgical care.

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ANNEXES

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

- Annex 16A. Search Terms and Bibliographic References per Country
- Annex 16B. WHP Guidelines for Safe Surgery 2009, Objective 10: Hospitals and Public Health Systems Will Establish Routine Surveillance of Surgical Capacity, Volume, and Results

NOTE

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

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