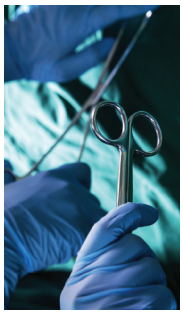

Chapter 18

Costs, Effectiveness, and Cost-Effectiveness of Selected Surgical Procedures and Platforms

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INTRODUCTION

This volume has shown that universal provision of a package of essential surgical services would avert an estimated 1.5 million deaths per year, or 6–7 percent of all avertable deaths in LMICs (Debas and others 2006; Mock and others 2015). Although approximately 234 million surgeries are performed worldwide each year, the distribution is very inequitable (Funk and others 2010). Nearly two billion people live in areas with a density of less than one operating room per 100,000 population (Funk and others 2010); in high-income countries (HICs), the density is 14 per 100,000. With this scarcity of surgical services in low- and middle-income countries (LMICs), the need for scaling up is imperative.

Challenges to the implementation of surgical services in resource-limited environments are substantial and include limited human resources, transportation systems, and access to electricity and water (Hsia and others 2012; Kruk and others 2010). Moreover, evidence on the different attributes of scaling up is insufficient. Scaling up requires increasing the share of current income devoted to spending on health, as well as major investments in facilities and human resources.

Priority interventions in LMICs are those that are cost-effective and reasonable in cost; *reasonable* is defined relative to the prevalence of the condition and size of the government health budget. Feasibility is important, particularly in low-income countries (LICs), which lack many health systems resources. Some deficiencies can be remedied if cost and cost-effectiveness considerations identify additional investments that provide good value. For example, purchasing more radiotherapy equipment or training additional personnel may make a substantial difference. Other deficiencies are harder to remedy. LMICs typically have limited ability to manage resources, which restricts how referral or organized screening systems work.

In this chapter, we discuss evidence showing that some types of surgery can be both highly cost-effective—saving lives or improving the quality of life—and affordable. We focus on a set of surgical interventions that can be undertaken at first-level hospitals, or in some cases, in clinics or mobile facilities. These interventions include selected emergency surgeries, surgeries associated with reproductive functions, and nonemergency surgeries. We do not cover other types of surgery that also may be cost-effective and even modest in cost but that are more suited to referral hospitals in LMICs, namely, surgery for cardiovascular disease, cancer, organ transplantation, and neurosurgery.

Surgical interventions for cardiovascular disease, such as left main coronary artery bypass graft surgery and percutaneous transluminal coronary angioplasty, have

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been very cost-effective in certain population groups in HICs, compared with medical management (Tengs and others 1995); this outcome is likely to apply to some population groups in LMICs. Basic surgical interventions for cancer treatment are likely to be cost-effective and, in some cases, feasible at the first-level hospital, for example, oophorectomy, simple hysterectomy, radical mastectomy, and colectomy. Very few cost-effectiveness results are available on these interventions, surveyed in Horton and Gauvreau (2015) and not discussed further here. Kidney transplants, although relatively costly, may be cost-effective (Tengs and others 1995). We do not cover neurosurgery, such as surgery to treat epilepsy or to treat infant hydrocephalus, although Warf and others (2011) show that such surgeries can be cost-effective in Sub-Saharan Africa. Cost-effectiveness of reproductive surgery is considered in volume 2, *Reproductive, Maternal, Newborn, and Child Health* (Black and others forthcoming). Dental surgery is not covered because of a lack of studies using quality-adjusted life year (QALY), disability-adjusted life year (DALY), life year saved (LYS), and death-averted outcome measures.

The set of conditions covered in the chapter is listed in annex 18A and includes interventions discussed in other chapters in this volume; chapter 1 provides a more comprehensive list of the detailed procedures considered. These are surgery types that can feasibly be undertaken at first-level hospitals, although they may also be undertaken at second-level hospitals, often when urgent cases arrive at these emergency units. Some can be undertaken in specialized facilities, for example, a cataract hospital, a specialized mobile facility, a short-term surgical mission focused on specific surgical conditions, or a trauma center.

We briefly summarize the literature on the cost-effectiveness of different ways of organizing facilities for surgery. Equity and affordability are important considerations when prioritizing care. We review both of these issues before discussing data limitations and presenting conclusions. This chapter uses World Health Organization (WHO) geographical regions: Africa, the Americas, South-East Asia, Europe, Eastern Mediterranean, and Western Pacific.

WHY ARE COST-EFFECTIVENESS DATA USEFUL FOR SURGERY?

Conditions potentially treatable by surgery constitute a significant proportion of the global burden of disease. Bickler and others (chapter 2) estimate that scaling up the recommended list of procedures at first-level hospitals could prevent 1.4 million deaths annually—3.2 percent of the global number—taking into account the proportion for which treatment can be expected to be successful. An additional 0.9 percent of deaths could be averted by advanced surgical care delivered at specialized clinics to treat nonemergency conditions, such as cataracts, cleft lip and palate, congenital heart anomalies, neural tube defects, and obstetric fistula. In addition, surgery could reduce the substantial burden of disabilities.

Cost-effectiveness data can provide important support for additional investments in surgical facilities at first-level hospitals. The data can help identify high-priority procedures from a cost-effectiveness perspective, leading to an analysis of the resources required to expand their availability.

The cost-effectiveness data have limitations. In the United States, a major expansion of access to surgical facilities occurred after the 1930s (chapter 4), while cost-effectiveness analysis in health became widespread only during the 1970s. By the 1970s, it was not easy to conduct cost-effectiveness studies of many basic and nonelective surgical techniques because they had become "usual care." Much of the more recent cost-effectiveness literature for HICs focuses on refinements, such as minimally invasive techniques, for example, laparoscopic surgery; new types of surgery that become more relevant in aging populations, for example, joint arthroplasty; or new, and often disposable, technologies, such as mesh or stents, and compares these newer interventions with more basic forms of surgery. This literature is of less immediate interest to policy makers in LMICs.

Cost-effectiveness data are more feasibly obtained in LMICs as services expand, given that "usual care" can mean "no intervention" in areas with little or no access to surgery. In LMICs, however, there are fewer studies of emergency procedures and a greater number of studies of elective procedures and nonurgent procedures. Much of the evidence is from surgical missions or nongovernment surgical facilities, and this evidence has limitations. Mission data tend to underestimate costs, because the costs of facilities and follow-up care tend not to be included; nongovernment facilities often have foreign support or foreign personnel, and their costs are not representative.

The organization of surgical services affects cost-effectiveness; in particular, the cost effectiveness of first-level hospitals differs from that of second-level hospitals, specialty hospitals, and surgical missions. Cost-effectiveness of government hospitals may differ from that in hospitals operated by charitable organizations. We briefly summarize some comparative cost-effectiveness data for surgical missions compared with first-level hospitals, specialized hospitals compared with first-level hospitals, and one

example of a government-run hospital compared with a nongovernment-run hospital. Shrime and others (chapter 13) discuss in more detail the cost-effectiveness of surgical missions compared with first-level hospitals.

COST-EFFECTIVENESS OF SURGICAL INTERVENTIONS

Methods

Several different metrics can be used to measure the cost-effectiveness of surgical interventions. For LMICs, the cost per DALY averted is often used, as are older variants, such as cost per life year saved (LYS) or cost per death averted. For HICs, the cost per QALY gained is often used. The DALY and QALY measures allow comparisons to be made between interventions that do not necessarily save lives but may substantially improve the quality of life or reduce disabilities; deaths averted or LYS only allow comparisons to be made between life-saving interventions. Some studies do not assess disability and measure only LYS. We have to be cautious because studies do not use the same outcome measures; the underlying methodologies and assumptions also vary. Accordingly, we use such data to illustrate broad tendencies.

The studies cited mainly use DALYs averted or QALYs gained. Although DALYs and QALYs are not identical (the weights attached to different conditions are not the same), we treat them as roughly equivalent. We have converted all published cost data if expressed in another currency into U.S. dollars, using the market exchange rate of the year the data were collected. We have also converted costs to 2012 U.S. dollars to allow comparisons, first inflating local currency units to 2012 using the consumer price index of the relevant country, and then converting using the average exchange rate for 2012. Throughout the discussion, we refer to the costs and cost-effectiveness in 2012 U.S. dollars.

There is a large literature on methodology (see, for example, Drummond and others 2005), and the debates continue. For example, many of the studies surveyed use discounting to weight costs and benefits occurring further in the future, commonly using the 3 percent social discount rate. More recently, some have argued that discounting is not appropriate (Murray and others, 2012). Past efforts applied different preference weights at different ages, weighting deaths of prime-age working adults more heavily than those of children or the elderly, but this is no longer common practice. Differences in methodology can change the cost-effectiveness ranking of different procedures; for example, the decision as to whether, and by how much, to discount the future has major impacts on interventions affecting children.

The data in tables 18.1 through 18.4 come from various sources. A systematic search of the literature on all surgical costs was undertaken from March through July 2013, with a supplemental search in 2014 in PubMed since 2000 in English. The search combined

Table 18.1 Cost-Effectiveness of Trauma and Emergency Surgery, Excluding Obstetric Emergencies

Source	Condition	Country	Cost per outcome US$	Unit of outcome	Currency, US$	Cost per outcome, 2012 US$
Gosselin and Heitto 2008[a]	Trauma	Cambodia	$77	DALY averted	2006	87
Gosselin, Maldonado, and Elder 2010[b]	Trauma	Haiti	$223	DALY averted	2008	302
	Trauma including burns	Nigeria	$172	DALY averted	2008	218
Gosselin, Gialamas, and Atkin 2011[c]	Acute orthopedic conditions	Haiti	$343	DALY averted	2010	362
Kong and others 2013[d]	Acute appendicitis	South Africa	$1,714	LYS	2011	1,611

Note: DALY = disability-adjusted life year; LYS = life year saved; n.a. = not applicable.

a. Modeled based on costs and estimated DALYs saved for all admissions during a three-month period for a trauma hospital, excluding outpatients.

b. Modeled based on costs and estimated DALYs saved associated with all admissions for a trauma hospital during a three-month period. A higher proportion in Nigeria was life-saving surgery; Haiti includes burns.

c. Included 93 patients during 5 one-week relief missions following earthquake, all acute conditions (debridements, amputation, stump revision, few fixations).

d. Microcosting of appendicitis surgery, combined with estimate from Jha, Bangoura, and Ranson (1998) that appendectomy saves 1.86 life years, based on mortality risks for complicated appendicitis. In South Africa, 36 percent were uncomplicated, 57 percent had perforation, 8 percent had other pathologies and were excluded.

terms for specific surgical interventions listed in annex 18A with economic terms as well as with names of all LMICs and regions containing groups of LMICs. Items determined to be relevant included outcomes such as cost per LYS, per QALY gained, or per DALY averted. From the 124 articles found on all surgeries, we included 29 cost studies that were for essential surgeries covered in this chapter. The search for LMICs identified 36 cost-effectiveness studies, of which 17 were also captured in a systematic survey by Grimes and others (2014) that used slightly different search criteria. We augmented our search with another systematic survey by Chao and others (2014), which added three articles not obtained from either of the searches. Of these, we omitted 16 studies that were not related to essential surgeries, or that focused on circumcision, which is treated in volume 2 of this series. The result was a total of 25 cost-effectiveness studies included in this review. Databases other than PubMed were not included and would have potentially yielded additional studies. Additional articles published between the time of the original search and the publication date of this chapter were not included.

This systematic search was augmented by selective searches of the literature for HICs using more limited search terms for potentially important interventions for which little or no literature turned up for LMICs, such as trauma centers. Results for HICs are discussed in the text but not included in the tables. Other useful published systematic searches, including studies of HICs, include Brauer and others (2005) and Dougherty and Howard (2013), both for orthopedic surgery in HICs, and Lansingh, Carter, and Martens (2007) for cataracts in LMICs and HICs. Annex 18B provides the search statistics.

Articles included were also graded using the Drummond and others (2005) checklist, as used by Chao and others (2014), to provide a quality score for each article (annex 18c). The quality score data are included in the tables. Most of the studies were graded as 7 or above out of 10, with the one exception of nonemergency surgery, where three of the seven articles were graded lower than 7 out of 10. The checklist is similar but not identical to the Consolidated Health Economic Evaluation Reporting Standards checklist (Husereau and others 2013). Some variations occurred across the studies with regard to methodology. For example, although many adopt a societal perspective for the analysis, others use the health system perspective.

Articles chosen for inclusion typically compare a surgical intervention with usual care, that is, no surgical intervention. Comparisons of two different surgical interventions were generally not included. The focus was on identifying a base set of candidate interventions that are cost-effective at first-level hospitals and another set that are not cost-effective. In HICs, where surgical capacity is much more broadly available and the interventions described have become usual care, the focus of recent literature has shifted to comparisons between different surgical interventions for the same condition or sometimes surgical interventions in comparison with other treatment, for example, a surgical versus a medical approach to cardiovascular disease, or surgery for a musculoskeletal condition versus a corrective device. We reference some of these studies in the text but do not include them in the tables.

We use the term *cost-effectiveness*. Unless otherwise specified, we use incremental cost-effectiveness ratios (ICERs); when comparing surgical treatment to "no intervention," this can readily be described as cost-effectiveness. When we start comparing two different interventions, we need to be more precise. The cost-effectiveness ratios presented are point estimates, but individual studies often conduct sensitivity analysis and provide ranges for their estimates.

How can we compare cost-effectiveness results across a range of countries? How transferable are these results across different environments? Care must be taken in extrapolating results. Costs of interventions vary considerably across countries. The same intervention may have different effectiveness when implemented in different environments. Disease prevalence differs, comorbidities differ, and usual care may be vastly different.

The approach suggested by the Commission on Macroeconomics and Health (WHO 2001) is that interventions costing less than the per capita gross domestic product (GDP) in LMICs are "very cost-effective," and those costing less than triple the per capita GDP are "cost-effective." Although this approach has not typically been applied to HICs, a major study of Australia (Vos and others 2010) categorized a cost per QALY gained of less than $A 50,000 as cost-effective, and less than $A 10,000 as very cost-effective. Studies of the United States have used a similar yardstick for cost-effectiveness; a threshold of £20,000–£30,000 has sometimes been used for the United Kingdom (NICE 2008).

Trauma and Emergency Surgery

Trauma Care

Trauma care saves lives; 77 percent of the deaths preventable by surgery are from injuries, representing 1.04 million deaths annually (chapter 2). Every year, 20–50 million injury survivors are left permanently

disabled, most often because of musculoskeletal injuries (Debas and others 2006).

Trauma care can be very cost-effective (table 18.1). Gosselin and Heitto (2008) show that at US$87 per DALY averted, pure trauma hospitals in Cambodia could be very cost-effective. Gosselin, Maldonado, and Elder (2010) evaluate two trauma hospitals in Haiti and Nigeria to find cost-effectiveness ratios of US$302 and US$218 per DALY averted, respectively. The differences in cost-effectiveness were mainly due to different labor cost structures, as well as differences in case mix: the hospital in Haiti includes a burn unit, whereas the one in Nigeria does not. A study of five short relief missions to Haiti following the 2010 earthquake suggested that the cost per DALY averted was US$362 for acute orthopedic conditions (Gosselin, Gialamas, and Atkin 2011).

Emergency Surgery

Although emergency surgery is life saving, it is more difficult to find cost-effectiveness estimates for interventions such as obstructed airway, bowel obstruction, perforation, and cholecystectomy. Appendectomy may be emergency surgery, depending on whether there are complications and sepsis. Kong and others (2013; see table 18.1) estimate that appendectomy costs were US$1,611 per LYS for South Africa. A study for Guinea by Jha, Bangoura, and Ranson (1998) finds appendectomy to be very cost-effective for emergency cases.

Reproductive Surgery

Selected maternal and neonatal conditions avertable by surgery account for 234,000 deaths annually (Bickler and others, chapter 2 of this volume). The major conditions included are maternal hemorrhage, obstructed labor, abortion, and neonatal encephalopathy. Table 18.2 summarizes some of the cost-effectiveness results for reproductive surgery.

Abortion and Early Pregnancy Loss

Early pregnancy failure is a common occurrence that affects one-third of early pregnancies (Wilcox and others 1988) and one-fourth of all women (Warburton and Fraser 1964). Although the traditional treatment option for such pregnancies has been surgical evacuation of the uterus, medical treatment with misoprostol has been gaining popularity as a noninvasive alternative. Both surgical and nonsurgical treatments are acceptable in practice (Chen and Creinin 2008), but determining the best regimen to use in a given clinical scenario is not always clear. With regard to the cost-effectiveness of different methods, four strategies have been evaluated:

- Hospital-based dilatation and curettage (D&C)
- Hospital-based manual vacuum aspiration (MVA)
- Clinic-based MVA
- Medical abortion using misoprostol.

The World Health Organization (WHO) recommends vacuum aspiration (manual or electric) and medical abortion as the preferred methods for first-trimester abortion (Grimes and others 2006; WHO 2003a). Findings from economic evaluations generally support these recommendations and suggest clinic-based MVA is the most cost-effective option for safe, first-trimester induced abortion. In Mexico and Nigeria, clinic-based MVA was found to be least costly and most effective, compared with D&C; in Ghana,

Table 18.2 Cost-Effectiveness of Reproductive Surgery

Source	Condition	Country	Cost per outcome	Unit of outcome	Currency (unless noted otherwise)	Cost per outcome 2012 US$
First trimester pregnancy termination						
Hu and others 2009[a]	First trimester pregnancy termination	Mexico	n.a.		Clinic-based MVA dominated	n.a.
Hu and others 2010[b]	First trimester pregnancy termination	Nigeria	n.a.		Clinic-based MVA is most cost-effective and cost saving	n.a.
		Ghana	n.a.		Medical abortion is most cost-effective and cost saving	n.a.

table continues next page

Table 18.2 Cost-Effectiveness of Reproductive Surgery (continued)

Source	Condition	Country	Cost per outcome	Unit of outcome	Currency (unless noted otherwise)	Cost per outcome 2012 US$
Intrapartum care						
Hu and others 2007[c]	Intrapartum care	Mexico	$300	DALY averted	2001 US$	$308
Goldie and others 2010[d]	Intrapartum care	India	$150–$350	LYS	2010 US$	$211–$492
Erim, Resch, and Goldie 2012[d]	Intrapartum care	Nigeria	< $550	LYS	2008 US$	< $696
Carvalho, Salehi, and Goldie 2013[d]	Intrapartum care	Afghanistan	$143–$178 (national model) $100–$400 (subnational model)	LYS	2006 US$	$215–$268 (national model) $151–$602 (subnational model)
Obstructed labor or cesarean section						
Adam and others 2005[e]	Management of obstructed labor	Southeast Asia	$38	DALY averted	2000 US$	$72
		Sub-Saharan Africa	$28			$82
Hounton and others 2009	Surgically trained medical officers for cesarean section	Burkina Faso	Obstetrician: $11,757 Clinical officer: $3,235 General practitioner: $200	Newborn life saved	2006 I$	Obstetrician: $5,080 Clinical officer: $1,398 General practitioner: $86
Alkire and others 2012[f]	Cesarean section for obstructed labor	49 LMICs	$304 (median) $251–$3,462 (range)	DALY averted	2008 US$	$384
McCord and Chowdhury 2013[g]	Emergency obstetric care	Bangladesh	$11	DALY averted	1995 US$	$15

Note: DALY = disability-adjusted life year; D&C = dilation and curettage; I$ = international dollar; LMIC = low- to middle-income country; LYS = life year saved; MVA = manual vacuum aspiration; n.a. = not applicable.

a. Model-based comparative analysis of three methods for first-trimester pregnancy termination: D&C, MVA, and medical abortion using a regimen of vaginal misoprostol.

b. Computer-based decision analytic model of induced abortion and its complications comparing unsafe abortion and three methods for safe, first trimester pregnancy: D&C, MVA, and medical abortion using misoprostol.

c. Maternal health policy model used to evaluate a package of care that includes safe abortion and surgical treatment of emergency obstetric care.

d. Maternal health policy model.

e. WHO-CHOICE cost-effectiveness analysis of a package of interventions that includes treatment of emergency obstetric care. Skilled attendance to allow appropriate early recognition and treatment of complications and timely referral to hospitals for more complex care require considerably more resources than community-based and antenatal care packages, but are effective in reducing maternal and neonatal morbidity and mortality and are highly cost-effective.

f. Modeling study.

g. Includes all emergency care at a hospital in Bangladesh for three months: obstetric emergencies are a large proportion and have higher cost-effectiveness than other emergency surgeries.

medical abortion using misoprostol was most cost-effective. In addition to being cost-effective, similar to studies in the United States, shifting to MVA outpatient services has been found to be cost saving (Levin and others 2009; Rausch and others 2012; Rocconi and others 2005). The promotion of medical abortion may have additional benefits by increasing access to safe abortion services, given the challenges of providing surgical services in many low-resource settings, and reducing overall costs of care. It also frees up surgical resources for other essential services for which there may be no nonsurgical options.

The overall implications of these findings from economic evaluations of the management of early pregnancy loss can be summarized as follows:

- The provision of safe abortion is the single most influential factor on health and economic outcomes.
- All else equal, shifting services from D&C to clinic-based MVA will provide equivalent or greater benefits and will result in fewer complications and lower costs.

Institutional Delivery: Emergency Obstetric Care

Overall, achievement of the Millennium Development Goals for the reduction of maternal mortality hinges on the extent of the provision of institutional care during the intrapartum period. Evidence shows that the best intrapartum care strategy is likely to be one in which women routinely choose to deliver in health centers, with midwives as the main providers but with other attendants working with them. Such care is variously referred to as *basic, primary, routine, basic essential obstetric care*, and most recently, *skilled care at the first level* (WHO 2005). Two cost-effectiveness analyses of maternal and neonatal care packages and means of distribution emphasize the potential of close-to-client care for normal and complicated cases—essentially encompassing basic essential obstetric care and basic emergency obstetric care, finding them among the most cost-effective options (Adam and others 2005; Bale and others 2003). More widespread availability of proximate services would increase the likelihood that women would have access if the need for emergency care were to arise in the antenatal or postpartum period (Campbell and Wendy 2006).

Moreover, because health centers are part of the health system, the affordability and sustainability of a health center intrapartum-care strategy are likely to surpass those of strategies distributed outside of the health system, such as traditional birth attendants or volunteer community workers. Accordingly, it is likely that a health center intrapartum-care strategy would be adequate to deal with most births and that this level fits well with the district approach to health systems. Minor variations on the strategy might be needed in some contexts. These variations relate to the cadre of skilled attendants—midwives or doctors—and the case for a hospital intrapartum-care strategy (Campbell and Wendy 2006).

Safe motherhood strategies, such as intrapartum care consisting of normal or assisted delivery, or comprehensive emergency obstetric care, are usually delivered as a package of services. The literature evaluates the cost-effectiveness of such strategies using packages of care. Family planning interventions and safe abortion services are central to reducing the maternal mortality rate in Afghanistan, India, and Nigeria (Carvalho, Salehi, and Goldie 2013; Erim, Resch, and Goldie 2012; Goldie and others 2010). However, these studies consistently find that further reductions would not occur without increasing access to high-quality intrapartum and emergency obstetrical care.

For example, in India, attainment of the fifth Millennium Development Goal of a 75 percent reduction in maternal mortality by 2015 would require investments targeting the intrapartum period, in addition to family planning and safer abortion. Including surgery in a package of maternal care also includes family planning, safe abortion facilities, facility-based basic emergency obstetric care, and quality comprehensive emergency obstetric care. The ICERs for increased coverage were in the range of US$211–US$492 per LYS, that is, 14 percent to 33 percent of GDP per capita in India and hence very cost-effective (Goldie and others 2010; table 18.2). The same package of care costs less than US$696 per LYS in Nigeria (Erim, Resch, and Goldie 2012) and less than US$268 in Afghanistan (Carvalho, Salehi, and Goldie 2013).

Adam and others (2005) find skilled care at birth consisting of basic emergency obstetric care and comprehensive emergency obstetric care to be cost-effective in LMICs, such as those in South and Southeast Asia and Sub-Saharan Africa. In 2000, a package of care consisting of basic antenatal care and skilled attendance at birth had an incremental cost of US$21.72 in Sub-Saharan Africa and US$36.64 in South and Southeast Asia, compared with the option of antenatal care without skilled attendance at birth. This package amounted to an additional US$67.3 million and US$96.2 million, respectively, in the entire Sub-Saharan African and Southeast Asian regions, including South Asia, for universal access (Adam and others 2005).

Two studies explore increasing access through task-shifting and the training of lower-level general practitioners to overcome staff shortages of physicians for performing emergency care and surgical services. Kruk and others (2007) show that lower-level cadres can provide surgical services at a reasonable cost in rural Mozambique. Hounton and others (2009) look at the cost-effectiveness of training different cadres of health workers to perform cesarean sections, finding that training of general practitioners appeared effective and cost-effective.

Nonemergency Surgery

Nonemergency surgery, although less often life saving, can still alleviate a considerable proportion of the

global burden of disease. Cost-effectiveness data are summarized in table 18.3, panels a (congenital defects, hernia, and nonemergency orthopedic conditions) and b (selected types of eye surgery).

Congenital Defects

Cleft lip/palate is one of the more common birth defects, occurring in 1 out of 500–700 births (Magee, Vander Burg, and Hatcher 2010). If untreated, it can lead to problems with eating, language development, and hearing; in severe cases, it is associated with higher mortality in early childhood. Data from surgical missions for cleft lip/palate surgery in four countries (Magee, Vander Burg, and Hatcher 2010; Moon, Perry, and Baek 2012) suggest that this surgery is very cost-effective. Moon, Perry, and Baek (2012) estimate the average cost for a mission in Vietnam was US$86/DALY averted; Magee, Vander Burg, and Hatcher (2010) estimate that the cost over eight missions to four countries ranged from US$9 to US$108 per DALY averted. Surgical mission data do not typically account for the costs of the surgeon's time or the facilities.

Table 18.3 Cost-Effectiveness of Nonemergency Surgeries

a. Selected surgeries

Source	Condition	Country	Cost per outcome	Unit of outcome	Currency	Cost per outcome, 2012 US$
Congenital defects						
Corlew 2010[a]	Cleft lip, cleft palate	Nepal	$29	DALY averted	2005 US$	$40
Magee, Vander Burg, and Hatcher 2010[b]	Cleft lip, cleft palate	8 missions (5 Vietnam, 1 each Nicaragua, Kenya, Russian Federation)	$7–$96	DALY averted	2008 US$	$9–$108
Moon, Perry, and Baek 2012[c]	Cleft lip, cleft palate	Vietnam	$68 ($87 imputing volunteer time)	DALY averted	2003 US$	$67 ($86 imputing volunteer time)
Hernia						
Shillcutt, Clarke, and Kingsnorth 2010[d]	Inguinal hernia	Ghana	$13	DALY averted	2008 US$	$11
Shillcutt and others 2013[e]	Inguinal hernia	Ecuador	$96	DALY averted	2011 US$	$101
Nonemergency orthopedic surgery						
Gosselin, Gialamas, and Atkin 2011[f]	Various	Dominican Republic, Nicaragua	$362	DALY averted	2009/10 US$	$359
Chen and others 2012[g]	Various	Nicaragua	$476	DALY averted	2011 US$	$540

Source:

Note: DALY = disability-adjusted life year.

a. Calculated from one center in Kathmandu specializing in cleft lip (402 cases) and palate (166 cases) in one year.

b. Only includes mission costs, not local hospital costs.

c. Based on costs of 16 missions from Korea to Vietnam during 1996–2010. Excludes cost of hospital space and depreciation of hospital facilities.

d. Based on five-day mission to four first-level hospitals in Ghana. Used Liechtenstein repair, day surgery.

e. Based on 2 two-week missions. Used Liechtenstein repair, day surgery.

f. Volunteer surgical mission of one week, 30 patients (knee osteoarthritis, fractures, dislocations, amputations, injured nerves); excludes building costs, maintenance, utilities. Cost-effectiveness from Nicaraguan provider perspective.

g. Some 117 patients over three missions 2009–10; less than 10 percent were acute conditions; congenital malformations (club foot, developmental dysplasia of hip) were 32 percent. No salary cost for surgical volunteers, but travel and lodging cost is included.

b. Cataract Surgery and Similar Eye Surgeries

Source	Condition	Country	Cost per outcome	Unit of outcome	Currency	Cost per outcome, 2012 US$
Baltussen and others 2005[a]	Trachoma	Seven WHO subregions AFR-E (lowest cost per DALY averted) to EMRO-D	$13–$78	DALY averted	2000 I$	$7–$28
Lansingh, Carter, and Martens 2007[b]	Cataracts	Nine LMICs	$4–$253	QALY gained	2004 US$	$6–$423
Wittenborn and Rein 2011[c]	Laser surgery for glaucoma	Barbados	$1,528	DALY averted	2005 US$	$2,314
		Ghana	$1,771			$1,989
Baltussen and Smith 2012[d]	Trachoma (trichiasis surgery)	Sub-Saharan Africa (AFR-E); South Asia (SEA-D)	$71–$90 AFR-E $285–$374 SEA-D (80–95% coverage)	DALY averted	2005 I$	$31–$40 AFR-E $106–$140 SEA-D
	Cataracts		$116 AFR-E $97 SEA-D	DALY averted	2005 I$	$36 AFR-E $51 SEA-D

Note: AFR-E = the WHO subregion in Africa with the highest mortality rates; DALY = disability-adjusted life year; EMRO-B = the WHO subregion in the Eastern Mediterranean with the highest mortality rates; I$ = international dollar; n.a. = not applicable; QALY = quality-adjusted life year; SEA-D = the WHO subregion in Southeast Asia (including South Asia) with the highest mortality rates.

a. WHO-CHOICE model; extracapsular cataract extraction for cataracts.

b. Literature survey 1996–2006. The authors find 5 studies with calculated cost-effectiveness for first eye (4 countries), and use cost data from another 11 countries to calculate cost-effectiveness.

c. Laser surgery only for syndromic referral; treatment with full American Academy of Ophthalmology guidelines is more costly, as is treatment on incidence, and screen and treat.

d. Newer version of model in Baltussen and others (2005).

An estimate by Corlew (2010) for a nongovernment-supported program at Katmandu Model Hospital, using local physicians, was US$40 per DALY averted for Nepal; these DALYs were age weighted. The program also provides orthodontic services and speech therapy, which are not included in the short-term missions. Cost data from a permanent facility are likely to be a better guide for ongoing programs than cost data from missions. All of these estimates are in the very cost-effective range.

Clubfoot is a less common condition, and can be treated nonsurgically as well as surgically. One estimate of surgical cost for New Zealand (Halanski and others 2009) yielded an estimated cost per DALY averted that would fall in the very cost-effective range for New Zealand; however, no cost-effectiveness results were found for LMICs.

Hernia

Repair of inguinal hernia is one of the most commonly performed operations in the Americas (Shillcutt and others 2013). In Sub-Saharan Africa, 175 people per 100,000 need this operation each year (Shillcutt, Clarke, and Kingsnorth 2010). The lack of access to timely care leads to complications and ultimately more expensive emergency surgery, and it increases mortality and morbidity. Estimates from surgical missions suggest that the repair was very cost-effective in Ecuador at US$101 per DALY averted (Shillcutt and others 2013) and Ghana at US$11 per DALY averted (Shillcutt, Clarke, and Kingsnorth 2010).

Estimates from HICs confirm the findings that surgery for abdominal, inguinal, umbilical, and femoral hernia is very cost-effective (Coronini-Cronberg, Appleby, and Thompson 2013). A comparative study of three different options for inguinal hernia repair for the United States (Stylopoulos, Gazelle, and Rattner 2003) suggests that laparoscopic repair was more cost-effective than open methods, each compared with no intervention, largely because the greater effectiveness possibly offset the higher cost. However, laparoscopic methods are not widely available in LMICs at first-level hospitals. One study for the United States (Stroupe and

others 2006) points out that cost-effectiveness depends on the population considered; repair is much less cost-effective for men with asymptomatic or minimally symptomatic hernia.

Recent literature in HICs examines the cost-effectiveness of devices and technologies that may require expensive purchased inputs. Most LMICs cannot afford these inputs. In India, Gundre, Iyer, and Subramaniyan (2012) have shown that using polyethylene mesh for inguinal hernia meshplasty is equally safe and effective but 2,808 times cheaper compared with the use of commercially available polypropylene mesh.

Nonemergency Orthopedic Procedures

In 1990, an estimated 1.7 million people worldwide had hip fractures, a number that is expected to increase to 6 million annually by 2050 (chapter 3). Estimates for 2002 were that osteoarthritis was the fourth most important source of disability, mainly due to osteoarthritis of the hip and knee (chapter 3). As populations in large LMICs age, the demand for nonemergency orthopedic procedures is expected to grow dramatically.

Estimates of the cost per DALY averted for nonemergency surgical missions are similar to those for trauma surgery. One study of 30 patients (Chen and others 2012, table 18.3A) estimates the cost of a mission to Nicaragua to be US$540 per DALY averted; another study of 117 patients and three missions estimates the costs for the Dominican Republic and Nicaragua to be US$359 per DALY averted (Gosselin, Gialamas, and Atkin 2011). Both studies likely underestimate the costs of such treatment on an ongoing basis. The former study does not include costs for space, maintenance, and utilities; the latter does not include salary costs, although it includes travel costs for the volunteers. These costs per DALY averted are similar to those of the emergency surgery missions and likely suffer from similar methodological issues in costing. However, the costs per DALY averted are so modest that even if all costs are included these interventions are likely to remain very cost-effective. Mission data in general are likely to be somewhat artificial. To take maximum advantage of the availability of surgeons, it is likely that a significant amount of organization has to occur before the mission to line up a suitable number of surgical appointments. Similarly, following the mission, follow-up is likely to be required by the local hospitals and health facilities. Neither of these inputs is generally included in the mission cost. The caseload and case mix for missions is not representative of that seen in a regular hospital. Missions may aim not to have downtime, while ongoing surgical facilities in LMICs may have more downtime. Missions have the advantage of economies of scale, that is, a number of similar surgeries are grouped together. Nonspecialized hospitals could conceivably try to do similar grouping, for example, perform orthopedic surgery on one specific day of the week, but doing so requires managerial capacity that is scarce in many of these settings.

Data from HICs confirm that there are cost-effective, nonemergency orthopedic procedures. Hip arthroplasty is very cost-effective in the United States (Chang, Pellissier, and Hazen 1996), although some of the assumptions, such as the cost savings anticipated in the United States from custodial care in the absence of surgery, are unlikely to apply in LMICs. Dougherty and Howard (2013) show similar findings for the United Kingdom, but the costs per QALY gained are higher than for the United States; James, St Leger, and Rowsell (1996) find that hip arthroplasty is very cost-effective in the United Kingdom. This operation is likely to become increasingly common in LMICs as populations age.

Knee arthroplasty costs at least twice as much as hip arthroplasty per DALY averted in both the United Kingdom and the United States, but it may also be cost-effective (Chang, Pellissier, and Hazen 1996; James, St Leger, and Rowsell 1996; Lavernia, Guzman, and Gachupin-Garcia 1997). However, Dougherty and Howard (2013) find that hip arthroplasty in the United Kingdom is twice as costly as knee arthroplasty, although their work is a literature survey and the underlying studies may not all use the same methodology. James, St Leger, and Rowsell (1996) suggest that other interventions in the United Kingdom, including those for spinal discectomy, carpal tunnel syndrome, and Dupuytren's contracture, were also very cost-effective, but that flexor tenosynovectomy costs more per DALY averted, and some operations had negative cost-effectiveness. The sample numbers in this study for interventions other than knee and hip arthroscopy were fairly small. Dougherty and Howard (2013) also provide cost-effectiveness results for other orthopedic procedures for the United States.

Cataracts

The number of blind persons globally increased from 38 million in 1990 to 124 million in 2002 (Resnikoff and others 2004; Thylefors and others 1995). Cataract disease is the cause of approximately 48 percent of the cases of total blindness worldwide (Resnikoff and others 2004); a rapidly aging population in many countries will continue to exacerbate the prevalence of visual impairment as a result of cataract disease. The WHO and the International Agency for the Prevention of Blindness joined forces in 1999 to respond to the problem, resulting in the launch of VISION 2020: The Right to Sight global initiative (Pizzarello and others 2004). The chief

goal of this program is to eliminate avoidable blindness by 2020; if the planned interventions succeed, an estimated 52 million persons will have their sight saved, with the concurrent avoidance of 429 million blind person-years and an economic gain of US$102 billion (Frick and Foster 2003). To achieve this lofty target, one of VISION 2020's specific objectives is to increase the availability of cataract surgery globally by raising output and training ophthalmic surgeons, especially in LMICs.

Cataract surgery is a routine intervention, and demand is expected to increase substantially as populations age. Knowledge of the cost-effectiveness of cataract surgery is essential if decisions on health care spending are to be as objective as possible.

Baltussen and Smith (2012, table 18.3B) estimate the cost-effectiveness of cataract surgery via extracapsular cataract extraction (ECCE) with posterior chamber intraocular lens implantation compared with no intervention, and find it to be very cost-effective in various WHO subregions, as is trichiasis surgery for trachoma. Another review (Lansingh, Carter, and Martens 2007) finds that cataract surgery, irrespective of country, is very cost-effective in all 15 countries considered (including 9 LMICs). The study also shows that cataract surgery is cheaper in an outpatient setting than with an overnight stay, and the phacoemulsification technique is costlier than either ECCE or manual small-incision cataract surgery. This review assesses the affordability of cataract surgery, defined as cost compared with per capita income, and finds that it is more affordable in Western Europe than in the United States; India is one country where it is most affordable among the LMICs of Asia (Lansingh, Carter, and Martens 2007).

A study in Nepal (Marseille 1996) confirms that cataract surgery is very cost-effective, although this particular study may not have fully incorporated all costs.

Several issues affect the cost-effectiveness of cataract surgery. Cost-effectiveness tends to be higher in the first eye treated than in the second, and the worse eye is usually prioritized. Most of the studies include a short follow-up period. Lundström and Wendel (2005) find that in Sweden, 80 percent of patients still enjoyed improved visual function seven years after surgery. This finding implies that a lifetime study horizon would be most appropriate for evaluating economic impact. With the rising life expectancy of populations, patients who receive the surgery are likely to live longer and enjoy a better quality of life with better vision for a longer period. This finding implies that the ICERs for cataract surgery are likely to be lower in the future, and cataract surgery will become even more cost-effective.

Wittenborn and Rein (2011) find that one-time surgery for self-referring patients was very cost-effective for both Barbados and Ghana; screening and using the full United States guideline treatment was not cost-effective in Ghana.

Organization of Surgical Services

The volume of surgeries undertaken is important. Effectiveness is higher and mortality rates are lower for surgeons who undertake the same operation many times in a year or in their careers; the same holds true for facilities and hospitals. In most cases, costs will likely be lower per operation at higher volumes because standardization typically reduces costs and allows the cost of any specialized equipment to be spread over a larger volume of patients.

For nonemergency surgery, specialized units that focus on specific types of surgery can be considered. These include specialized units performing cataract surgery, such as the Lumbini Zone eye hospital in Nepal (Marseille 1996); cleft lip and palate surgery, such as the one in Nepal (Corlew 2010); and fistula repair, such as centers in Ethiopia, Ghana, Nigeria, and Rwanda. To increase access, specialized units can be brought to local areas periodically, for example, through camps.

Cataract camps occur in South Asia with some regularity. Singh and others (2000) review the cost-effectiveness of three different types of facility offering cataract surgery in Karnataka state, India. They compare government camps, which were the least expensive for patients; nongovernment facilities, in which costs to patients were double that of the camps; and a government medical college hospital, in which costs to patients were three times that of the camps. The total costs of the camps and the nongovernment facility were similar; the cost of the medical college hospital was more than twice that of the others. The most cost-effective facility was the nongovernment one because of higher quality; the camps were intermediate, and the medical college the least cost-effective.

Specialized facilities bring tradeoffs. The facilities may offer greater effectiveness due to the specialized team and facilities, possibly even a lower cost due to economies of scale, but they may be more distant and hence be more costly to patients. To address the accessibility issue, it may be possible to bring specialized teams closer to more decentralized populations by offering a mobile camp, or by bringing specialized teams to first-level hospitals one day a week or one week every few months; however, doing so requires additional organizational capacity.

Finally, international surgical missions are a particular version of increasing access by bringing in specialized resources. Surgical missions occur in all areas: trauma

(Gosselin and Heitto 2008, table 18.1; Gosselin, Heitto, and Zirkle 2009); congenital defects (Magee, Vander Burg, and Hatcher 2010; Moon, Perry, and Baek 2012; hernia (Shillcutt, Clarke, and Kingsnorth 2010; Shillcutt and others 2013); cataract surgery (Marseille 1996); and nonemergency orthopedic surgery (Chen and others 2012; Gosselin, Gialamas, and Atkin 2011). Missions can increase capacity, and many surgical missions assist in building local capacity by helping train local surgical teams.

Shrime and others (chapter 13) examine the cost-effectiveness of surgical missions, as well as that of specialty hospitals supported by charitable organizations. Their conclusion is that short-term missions should be used only if no other option is available because evidence suggests that effectiveness is not as high as in more fixed facilities. This result is not surprising given that preoperative care and follow-up after surgery are not to the usual standard because of the logistics. They also examine the limited cost-effectiveness data on specialty hospitals, identifying the same study of cataract surgery (Singh, Garner, and Floyd 2000) discussed in this chapter, which shows that the charitable hospital had the most cost-effective outcomes of the three modalities considered. Cost-effectiveness data are available for other such facilities (Corlew 2010) for cleft palate, but no comparison is made to other facilities in the same country.

Trauma care is different from other surgical interventions. The emergency nature of this care, which also applies to obstetric emergencies, makes specialized trauma care facilities more difficult to establish. Urban areas in HICs can support trauma centers, provided that adequate rapid transportation is available. Trauma centers do exist in LMICS, for example, the ones analyzed by Gosselin, Maldonado, and Elder (2010) in Nigeria and Haiti.

Several studies for the United States have documented the effectiveness of a regionalized approach to trauma care, where critically injured patients are treated in a limited number of designated trauma centers (Durham and others 2006; MacKenzie and others 2010; Nathens and others 2000). Risk of death is 25 percent lower when care is provided in a regional, third-level trauma center than when it is provided in a nontrauma center hospital (MacKenzie and others 2010).

MacKenzie and others (2010) find that the cost-effectiveness ratio for treatment in a trauma center versus a nontrauma center in the United States fell in the cost-effective range. It is more cost-effective to treat more severely injured patients and those patients younger than age 55 years in a trauma center. This study uses comprehensive data available on both the effectiveness and the costs incurred in the year after injury for 5,043 patients treated at 69 trauma centers and nontrauma centers in 14 states of the United States (MacKenzie and others 2010).

WHO BENEFITS FROM SURGICAL SERVICES?

Major health shocks often lead to large out-of-pocket medical expenditures, induced borrowing, or the forced selling of assets and resulting in impoverishment in LMICs. Using data from 89 countries, Xu and others (2007) estimate that annually 150 million households across the world experience *catastrophic* health spending, defined as 40 percent or more of their nonfood expenditure on health care. Leive and Xu (2008) analyze household health care financing in 15 Sub-Saharan African countries; they find that in Burkina Faso, as many as 68 percent of households that had out-of-pocket health spending had borrowed money or sold assets to finance medical expenditures in the past year. In a larger study, Kruk, Goldmann, and Galea (2009) use data from 40 LMICs and find that more than 25 percent of households were forced to borrow money or sell assets to pay for health care costs. Other multicountry studies report similar large household financial costs associated with major health shocks (van Doorslaer and others 2007; Xu and others 2007).

Additional factors—such as access to care, willingness to pay, and the ability to pay—are important. As Weiser and others (2008) estimate, LMICs account for about 70 percent of the world's population but only perform about 26 percent of the 234 million annual surgeries. The large and often prohibitive costs of surgery are likely to be the greatest deterrent to obtaining care (Malhotra and others 2005). Accordingly, the majority of the literature on surgery in LMICs focuses on the barriers to access.

A few studies have examined the economic benefits of providing access to surgical care, particularly for poor people. For example, poverty and blindness are often found to be highly correlated (Gilbert and others 2008; Zimmer 2008). Accordingly, cataract surgery that prevents blindness may also prevent impoverishment. Kuper and others (2010) conducted a case-control study of cataract surgery in Bangladesh, Kenya, and the Philippines. The authors find that cataract surgery successfully increased the standard of living, as measured by monthly per capita expenditure, in the intervention group. The average increase in monthly per capita expenditure among patients who received the surgery was 36 percent in Kenya, 44 percent in Bangladesh, and 88 percent in the Philippines, compared with the control group, whose income did not change in Kenya and the Philippines and fell slightly in Bangladesh. Although the

economic benefits reached patients in all socioeconomic groups, the positive effect of blindness prevention was the greatest among the poorest participants.

Finger and others (2012), in a similar study in south India, find that cataract surgery was associated with higher standards of living and gainful economic activities. At least 45 percent of the participants receiving cataract surgery reported higher income levels after surgery, and the share of participants engaged in economic activities increased from 44 percent to 77 percent. The authors also found that the surgery improved the social status of widowed participants by increasing the rates of remarriage.

Two studies have modeled the economic benefits from cleft lip and palate surgery but without using household data on actual effects. Corlew (2010) for Nepal and Alkire and others (2011) for Sub-Saharan Africa estimate that considerable potential economic benefits were realized.

SURGICAL INTERVENTION COSTS[1]

The unit cost data in LMICs are not robust, but they have grown since the publication of Disease Control Priorities in Developing Countries, second edition, in 2006. Noting the paucity of literature on surgical costs and cost-effectiveness, Debas and others (2006) estimate costs of surgical services offered by first-level hospitals and community clinics that were not specific to interventions. The number of studies presenting economic information on surgical services and intervention-specific surgeries has increased since 2000; the majority of articles were published after 2006, and more than two-thirds were published after 2009. Most studies were conducted in South Asia and Sub-Saharan Africa, with the greatest body of literature emerging from India, followed by Bangladesh and Pakistan. Box 18.1 summarizes results for one such study, for Nepal. Much of the recent literature captures costs from third-level hospitals and focuses on specific diseases, surgical procedures, or platforms, with fewer studies providing estimates of surgical facility or ward costs from first-level hospitals.

Surgical Costs, by Type of Hospital

Total program costs for surgical care are driven by several factors, including the type and size of the hospital; whether it is public or privately owned and operated; and the surgical platform for delivering services, bed occupancy, and differences in salary structures. A study of five hospitals in India finds a range of annual program costs for different types of hospitals, including US$295,556 in a 60-bed charitable hospital; US$321,887 in a 400-bed first-level public hospital; US$1,314,935 in a private teaching hospital with 655 beds; and US$2,019,260 in a public third-level care hospital with 778 beds (Chatterjee and Laxminarayan 2013). In Ghana, a first-level hospital with 117 beds had annual surgical costs of US$66,492, which was two-and-a-half times less than a 200-bed mission hospital and four times less than a 110-bed third-level hospital (Aboagye, Degboe, and Obuobi 2010). These surgical program costs in India and Ghana vary considerably from previous regional estimates attributable to surgical patients, based on a standardized first-level hospital of 100 beds, which was US$1,124,728 for South Asia and US$1,471,575 for Sub-Saharan Africa (Debas and others 2006).

In LMICs, nongovernment surgical hospitals are a popular strategy for providing specialty care for trauma and orthopedics, especially among the urban poor who have limited access to surgical services. Nongovernmental hospitals are often characterized by higher costs because expatriate surgeons are working closely with national counterparts in a well-staffed and supplied facility, and the throughput of patients and surgical procedures performed throughout the year is higher. Two nongovernment surgical hospitals with 70 beds in Sierra Leone and 106 beds in Cambodia had annual operating budgets of US$214,113 and US$118,228, respectively (Gosselin, Thind, and Bellardinelli 2006; Gosselin and Heitto 2008). Labor costs constituted the major share of total surgical costs, with expatriate staff alone accounting for 30 percent of total costs in Cambodia. Medical surgical trauma centers operated by Médecins Sans Frontières cost US$1,112,665 per year in Nigeria's 70-bed urban hospital and US$1,864,822 per year in two surgical sites in Haiti, with one urban hospital with 60 beds and a second facility with 48 beds (Gosselin, Maldonado, and Elder 2010). Surgical unit costs are also available for platforms that deliver specialized services for cataract, cleft palate, or orthopedics through short-term outreach or medical missions; costs for these services are typically provided on a per trip or per person basis, and the services reach between 30 and 2,000 patients per year through time-limited medical missions (Chen and others 2012; Kandel and others 2010; Moon, Perry, and Baek 2012).

Surgical Unit Costs, by Condition

Recently published studies provide costs for disease-specific surgeries rather than surgical programs, adding an additional layer of variability depending on the

Box 18.1

Financial Sustainability of Scaling Up Surgical Services in a First-Level Facility: Case Study of Bayalpata Hospital in Nepal

Bayalpata Hospital in Nepal offers a unique case study for understanding the financial issues of scaling up (Maru and others 2011). This hospital serves as the referral hospital for the Achham district's primary health care centers, as well as for populations from two adjacent districts. It has three sources of funding:

- The government of Nepal (25 percent)
- Individual donors via the U.S.-based parent organization, Nyaya Health (approximately 50 percent)
- Foundation grants (25 percent).

The hospital includes outpatient and inpatient services and 24-hour emergency and delivery services, as well as laboratory and radiological (x-ray and ultrasound) diagnostic services. It has an onsite pharmacy and ambulance, and it implements community health programs. Its staff performs minor surgeries, such as repair of lacerations, abscess drainage, closed reductions, casting, and manual vacuum aspiration. It has two physicians and a nursing and midwifery staff but no surgeon. Without an operating room, there is no capacity for major surgeries.

The WHO developed an Integrated Management of Emergency and Essential Surgical Care (IMEESC) program in LMICs (WHO 2006). Bayalpata Hospital in Nepal upgraded its services under the IMEESC-Plus program (Maru and others 2011). This upgrade included the list of essential services proposed under IMEESC and two other components: community follow-up of surgical cases and quality improvement of hospital care. A general physician was trained to perform surgery, and visiting senior surgeons, both national and international, provided ongoing training.

The list of essential surgical services to be provided under IMEESC-Plus includes the following:

- Amputation of distal or proximal limbs
- Appendectomy
- Cesarean section
- Cholecystectomy
- Exploratory laparotomy
- Hernia repair
- Hydrocele reduction
- Surgical correction of head, chest, and abdominal trauma
- Surgical management of acute closed and open fractures
- Surgical management of wounds and burns.

A financial costing of this basic package of surgical services was undertaken. Based on Bayalpata Hospital's costing model, it was proposed that the overall construction and two-year operating costs of implementing the IMEESC-Plus model would be US$0.50 per capita in the district, which has a population of 266,000 (Maru and others 2011). The reported per capita health expenditure in Nepal in 2008–09 was US$24.8. Nearly 24 percent of this expenditure, or US$6, was borne by the government. If this incremental cost of US$0.50 were entirely publicly financed and scaled up across the country, it would amount to an 8.4 percent increase in the government's health budget.

Source: Maru and others 2011.

disease condition treated, the number and frequency of surgeries performed for a particular condition during a given period, and the surgical technique used. Table 18.4 provides a summary for four reproductive surgeries, two types of nonemergency surgeries, and cardiothoracic surgery.

Information is available on the costs of specific conditions for obstetric and gynecological services because of research and advocacy interest in increasing access to reproductive and maternal health services, including access to safe surgical abortion. In addition, obstetric and gynecological services typically constitute a large share of total inpatient activity at hospitals. Although variations across studies are typical, several studies have shown variations in the cost of procedures, such as cesarean section, within the same study (Levin

Table 18.4 Variations in Cost of Selected Surgical Procedures

Type of surgery	Location	Range of costs (2012 US$)	Source
Reproductive surgery			
Cesarean section	Africa	$41–$202	Honda, Randaoharison, and Matsui 2011; Hounton and others 2009; Kruk and others 2007; Levin and others 2003
	East Asia and Pacific	$548	Quayyum and others 2010
	South Asia	$121–$195	Khan and Zaman 2010; Sarowar and others 2010
Emergency obstetric surgery	Africa	$158–$202	Kruk and others 2007; Richard and others 2007
Surgical abortion	Various countries, types of hospital (public, private), and procedures	$8–$158 (D&C) $8–$103 (MVA)	Banerjee, Andersen, and Warvadekar 2012; Benson and others 2012; Henshaw and others 2008; Hu and others 2010; Koontz and others 2003; Levin and others 2009; PATH and M. O. H. Reproductive Health Department 2006; Sarowar and others 2010; Xia, She, and Lam 2011
Postabortion complications	Various countries; various procedures (cervical or vaginal lacerations less costly than vaginal perforations)	$58 (median) $18–$2,368	Asante, Avotri, and d'Almeida 2004; Erim, Resch, and Goldie 2012; Hu and others 2010; Levin and others 2003; Levin and others 2009; Rehan 2011; Vlassoff and others 2012; Vlassoff and others 2014
Nonemergency surgery			
Cataract surgery	India, various techniques	$30–$47	Muralikrishnan and others 2004
	Nepal, different camps	$63–$94	Kandel and others 2010
Hernia repair	Lichtenstein tension-free repair, various countries	$114 (Ghana), US$1,212 (China)	Gong and others 2011; Shillcutt, Clarke, and Kingsnorth 2010
	India, different hospitals and techniques	$270 (first-level)–$1,047 (third-level hospital, laparoscopic method)	Bansal and others 2012; Chatterjee and Laxminarayan 2013; Krishna and others 2012
Cardiothoracic surgery	India, public hospital	$3,315	Chatterjee and Laxminarayan 2013

and others 2003; Quayyum and others 2010). Some differences could be explained by differences in cost components.

In general, labor was the single largest component of total direct costs for all public hospital types, and indirect costs were the largest driver of costs for charitable and private hospitals. For some procedures, such as hernia repair and external fixations, drugs and materials constituted the largest share of direct costs. In general, costs tend to be lower at first-level hospitals than at second-level hospitals, probably because the more costly and specialized facilities are not available at the first-level hospital; private hospitals may be more costly than public; more specialized procedures and procedures using additional medical technologies are more costly; and costs are generally lower in countries with lower per capita incomes.

LIMITATIONS IN THE EVIDENCE BASE

As this review suggests, cost-effectiveness data for LMICs are scarce and may be affected by reporting bias. The data that do exist are heavily dominated by studies of surgical missions and nongovernment facilities. The data for missions likely understate the costs of ongoing services, and the effectiveness of government hospitals may be lower than that of hospitals run by charitable foundations. We have used data from HICs to supplement that from LMICs and to fill gaps. Cost-effectiveness findings depend on the context,

methodology, and assumptions made. However, there is reason to believe that a range of surgical interventions are cost-effective for LMICs.

The data limitations include the following:

- First, despite the increase in the number of economic evaluations, cost estimations, especially of unit cost data from first-level hospitals covering some or all of the recommended essential surgeries, are deficient. Specifically, most cost estimations have been disease specific and typically do not provide the costs of surgical wards. In addition, whatever cost estimates are available pertain to localized geographic areas and are typically derived from one or several hospitals, but they are not representative of the national health care system. In addition to heterogeneity in costs due to geography or conditions treated, inconsistency in data-collection methods and reporting formats limit the comparability of the data.
- Second, limited availability of empirical disability weights for various conditions in international health is an issue, mentioned, for example, in Shillcutt, Clarke, and Kingsnorth (2010) and Shillcutt and others (2013).
- Third, reliable information is critical if any attempt is to be made to base medical decisions on health and monetary considerations. The value of economic analysis is compromised if the quality of the data is poor. Methodologies for economic analyses appeared in the medical literature as early as the 1970s, with refinements over time (Blackmore and Smith 1998; Detsky and Naglie 1990; Jefferson, Demicheli, and Vale 2002). Although these methods are intended to reduce bias and improve the validity of economic analyses, these methodological principles are used infrequently (Blackmore and Smith 1998; Doubilet, Weinstein, and McNeil 1986). Calls have been made to standardize economic analysis methodology and for adherence to these principles in the medical literature (Doubilet, Weinstein and McNeil 1986; Drummond and Jefferson 1996; Jefferson, Demicheli, and Vale 2002).

Research that assesses the quality of cost-effectiveness data in specialties is available, including for gynecologic oncology (Manuel and others 2004), pharmacoeconomics (Iskedjian and others 1997), pediatrics (Ungar and Santos 2005), and nuclear medicine (Gambhir and Schwimmer 2000). These assessments, along with more generalized ones, systematically review studies to verify compliance with methodological criteria. Studies use various scoring methods; however, many check compliance with methodological principles thought to represent the minimum standards for medical economic analysis. Kruper, Kurichi, and Sonnad (2007) searched MEDLINE for 1995 to 2004 to identify articles that included economic analyses of surgical procedures. Their review indicates that published economic evaluations of surgical procedures in general do not follow accepted methodological standards, with fewer than half of the basic principles met by any given analysis. A comparison of nonsurgical versus surgical journals demonstrates a significant difference in compliance with methodological criteria, with much lower compliance in surgical journals. The average proportion of criteria met in the nonsurgical journals was slightly more than half, whereas in the surgery journals it was less than one-third. The surgical journals were also consistently lower in compliance with each individual criterion as compared with the nonsurgical journals, with less than 20 percent compliance for five criteria.

To defend the use of surgical interventions and treatment strategies in an environment that is becoming progressively more cost conscious, quality data become increasingly important. Those performing analyses in surgical areas need to increase their awareness of methodological standards so that the quality of surgical economic evaluations can improve, especially those evaluations in surgical journals. Wider promulgation of the methodological criteria in surgical journals or at surgical meetings may significantly improve the quality of economic analysis published in surgical journals or concerning surgical interventions.

Evidence gaps exist in the literature. No studies for LMICs were found for several conditions relevant for cancer, including mastectomy, hysterectomy, and blockages of the colon, or for obstetric fistula, despite the existence of some specialized units providing surgery for this condition in LMICs.

CONCLUSIONS

Disease Control Priorities in Developing Countries, second edition (DCP2), drew attention to the importance of surgical interventions in LMICs (Debas and others 2006). The authors showed that particular examples of surgical packages and platforms, such as providing cataract surgery, training lower-level medical staff for emergency obstetric surgery, and delivering surgery at first-level hospitals, were very cost-effective in many countries in South Asia and Sub-Saharan Africa.

Inclusion in Primary Health Care

Many countries are considering including surgical care in comprehensive primary health care. This primary

care initiative, described in *World Health Report* (WHO 2008), focuses on strengthening health systems through a series of reforms under the umbrella of primary health care. It is increasingly recognized that the provision and maintenance of a quality surgical service can strengthen the capacity to deliver other health services. Surgery is an essential component of efforts to reduce maternal mortality in childbirth, and it is of growing importance as the burden of noncommunicable diseases increases.

Global Initiatives

In response to the deficiencies in the capacity to deliver basic surgical services in LMICs, the WHO launched the Emergency and Essential Surgical Care (EESC) Project in 2004 (Bickler and Spiegel 2010). The IMEESC toolkit, supplemented by the text *Surgical Care at the District Hospital* (WHO 2003b), was developed to provide a basic training package. These teaching materials are based on the WHO's minimum standards and technologies for emergency and essential surgical care, and they are designed to strengthen the delivery of surgical and anesthetic services at primary health facilities.

The Global Initiative for Emergency and Essential Surgery Care (GIEESC) was established in 2005 to promote the EESC program and to address deficiencies in capacity for surgical care at the primary referral level in LMICs. The overall objective of the GIEESC is to stimulate collaboration among organizations, agencies, and institutions involved in reducing death and disability from surgically treatable conditions.

Future Priorities

Future priorities include development of appropriate surgical care models for all levels of care, based on local and regional characteristics and surgical needs. Cost-effectiveness and cost-benefit analyses of health systems implementation need to be undertaken. Further research on different modalities for provision of surgery, for example, the use of mobile clinics to reach underserviced areas, as well as the possibilities of task-shifting to reduce costs and increase affordability, would be useful. The evaluation of surgery as a prevention strategy in public health should include cost-effectiveness analysis of adequate, prompt, initial surgical treatment of injuries to prevent chronic disability from poorly diagnosed and treated survivable injuries, as well as elective treatment of hernia, hydrocele, otitis media, cataract, clubfoot, and nonemergency orthopedic conditions to prevent complications and disabilities.

This chapter has shown the potential for these interventions to be cost-effective and reasonable in cost. More work needs to be done to determine how best to organize these services to use economies of scale to reduce costs and increase effectiveness when specialized surgical interventions are consolidated. More work also needs to be done to estimate the investment costs of setting up these facilities, including training surgeons, providing specialty training, and equipping facilities appropriately.

ANNEXES

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

- Annex 18A. Search Terms Used to Identify Relevant Literature.
- Annex 18B. Flow Chart of Identification, Screening, and Eligibility of Included Cost Studies: Surgery.
- Annex 18C. List of Studies, Results, and Quality Scores

NOTES

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. All intervention costs in this section have been converted into 2012 U.S. dollars using the World Bank consumer price index or regional inflation rates, unless otherwise noted.

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