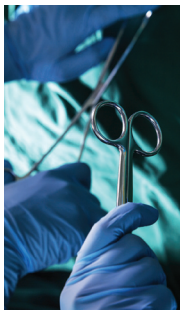

Chapter 4

General Surgical Emergencies

Colin McCord, Doruk Ozgediz, Jessica H. Beard, and Haile T. Debas

INTRODUCTION

In low- and middle-income countries (LMICs), at least 60 percent of the surgical operations performed are for emergencies. Contrary to widespread belief, it has been shown that the provision of treatment, which is often lifesaving for these patients, can be inexpensive. The staff and equipment required at first-level facilities for all categories of surgical emergency, including trauma (chapter 3) and obstetrics (chapter 5), are essentially the same. Accordingly, the treatment of general surgical emergencies requires little additional cost and should be part of the services offered at first-level facilities. This chapter

- Describes the common types of general surgical emergencies that can be treated at first-level hospitals in LMICs
- Provides the best available estimates of disease burden for the conditions for which these facilities are responsible
- Considers the cost and cost-effectiveness of providing this essential surgical service
- Describes the basic systems and the major bottlenecks to access
- Discusses the training and distribution of appropriately skilled staff.

The chapter is written for two primary audiences, health planners and surgeons in LMICs, to show each group how much can be provided and accomplished in very simple facilities, given adequate training and support.

Burden of Disease

The annual death rate from acute abdominal conditions in the United States in 1935 was 38 per 100,000 population, or 3 percent of all deaths in that year. General practitioners performed most surgeries; formal surgical training did not begin until 1937, when the American Board of Surgery was formed. By 1990, the death rate for acute abdominal conditions had fallen to 4 per 100,000 (CDC 1990; U.S. Department of Commerce 1935). The 90 percent reduction in mortality was due to increased access to operations, made possible by new facilities and more skilled staff in combination with the availability of antibiotics for infection, safer anesthesia, and blood for transfusions. The operations were not complicated. They are available today in LMICs, as are low-cost antibiotics, competent anesthesia, and blood; however, as in the United States in 1935, access to these operations is very limited. In the United States and in many other high-income countries (HICs) in 1935, all general surgical emergencies were responsible for 3 percent to 5 percent of deaths. This estimate may be as good as any other estimate of the burden of disease from these causes in LMICs, where there is little or no available surgical treatment.

Corresponding author: Colin McCord, MD, Columbia University (retired), cwm1@columbia.edu

The problems that limit access to surgical services in most LMICs are correctible, although serious and not easily overcome. They include the following:

- Insufficient number of surgically trained personnel, and the concentration of these personnel in major urban areas
- Lack of ongoing training and supervision in peripheral surgical units to supplement and upgrade skills
- Lack of efficient supply systems to ensure the availability of medications and materials
- Lack of adequate maintenance systems and personnel for diagnostic and therapeutic equipment
- Lack of affordable and reliable transport for patients between facilities so they can receive the appropriate level of care in a timely manner

Despite these handicaps, much can be done and is being done in very simple facilities with minimal support. This progress is possible because many of the important surgical problems can be resolved with uncomplicated, well-standardized procedures. A fully equipped, modern hospital is not essential to remove an appendix, close a perforated ulcer, drain an abscess, or even resolve most causes of intestinal obstruction.

Levels of Hospital Care

Definitions of the levels of hospital care were delineated in *Disease Control Priorities in Developing Countries*, second edition (Jamison and others 2006); as adapted, these levels are shown in table 4.1.

TYPES OF GENERAL SURGICAL EMERGENCIES

The list of surgically treatable emergencies commonly seen in LMIC hospitals is not long, but it includes problems that fall within the purview of several different specialties (Abdullah and others 2011; Curci 2012; Lavy and others 2007; McCord and Chowdhury 2003). Fortunately, 90 percent of the operations can be mastered by a person without full specialty qualification, so it is not necessary to have fully qualified surgeons, obstetricians, and traumatologists in every first-level hospital. With even a very limited ability to refer patients and intermittent supervision by qualified specialists, a very productive network for surgical care can be established (box 4.1).

Acute Abdominal Emergencies

Incarcerated and Strangulated Inguinal Hernias. Incarcerated hernia, a cause of intestinal obstruction,

Table 4.1 Definitions of Levels of Hospital Care

Terminology and definitions	Alternative terms commonly found in the literature
First-level hospital	Primary-level hospital
Few specialties—mainly internal medicine, obstetrics and gynecology, pediatrics, and general surgery	District hospital
Often only one general practice physician or a nonphysician clinician	Rural hospital
Limited laboratory services available for general analysis but not for specialized pathological analysis	Community hospital
50–250 beds	General hospital
Second-level hospital	Regional hospital
More differentiated by function, with as many as 5 to 10 clinical specialties	Provincial (or equivalent administrative area, such as county) hospital
200–800 beds	General hospital
Third-level hospital	National hospital
Highly specialized staff and technical equipment—for example, cardiology, intensive care unit, and specialized imaging units	Central hospital
Clinical services highly differentiated by function	Academic, teaching, or university hospital
Teaching activities in some facilities	
300–1,500 beds	

Source: Mulligan and others 2003.

is very common in Sub-Saharan Africa (Shillcutt, Clarke, and Kingsnorth 2010). About 4 in 1,000 hernias per year will become incarcerated, with a segment of intestine trapped inside the hernia sac; if untreated, these hernias can become gangrenous within several days. In 85 percent of the cases in a large review of incarcerated hernias, the bowel within the hernia sac was viable: it could be returned to the abdomen and the hernia repaired (van den Heuvel and others 2011). If the intestine is not viable, it must be removed and the divided bowel repaired. This is not a complicated procedure for an adequately trained surgeon. If bowel resection is not indicated, 99 percent of patients should survive; if bowel resection is required, 80 percent or more should survive, depending on the experience of the surgeon (Nilsson and others 2007).

Appendicitis. This condition is rare in isolated villages but increasingly common with development and a more "western" diet containing less fiber and more meat (Burkitt, Walker, and Painter 1972). Appendicitis is common in cities, towns, and more developed rural areas in many LMICs. Removal of an inflamed appendix is a straightforward procedure. Even in late cases complicated by perforation and abscess formation, drainage will resolve the acute problem unless generalized peritonitis has developed. Overall, including the late-presenting cases with perforation or a gangrenous appendix, 95 percent of patients can be expected to survive; this number reaches 99 percent in the hands of experienced surgeons (Mason and others 2012; Ohene-Yeboah 2006).

Intestinal Obstructions Caused by Adhesions, Volvulus, Worm Infection, or Intussusception. The most common cause of intestinal obstruction in LMICs is incarcerated hernia, but if no inguinal hernia is visible, then several other conditions should be considered. If treated early, all cases can be successfully managed with conservative measures or very simple abdominal operations; these conditions can become difficult problems if allowed to progress to a later stage.

Twisting (volvulus) of the intestine around an adhesion or scar from a previous operation or infection is becoming increasingly common. In many LMICs, it is the second most common cause of blocked intestine. Seen early, it will often resolve with tube decompression of the stomach and intravenous fluids. If an operation is necessary, simple division of the adhesion and untwisting of the intestine will resolve the problem at an early stage; at later stages, the twist can interfere with the blood supply, the intestine will die, and only removal of the dead intestine will prevent death of the patient (Adesunkanmi and Agbakwuru 1996; Madziga and Nuhu 2008).

Box 4.1

General Surgical Emergencies Commonly Seen in First- and Second-Level Hospitals

Acute abdominal conditions
- Incarcerated and Strangulated Inguinal Hernias
- Appendicitis
- Intestinal obstruction
- Complications of peptic ulcer, including perforated ulcer and bleeding ulcer
- Bleeding from esophageal varices
- Pelvic infections with abscesses
- Perforated typhoid ulcers
- Amebic liver abscess
- Gall bladder and bile duct disease

Respiratory obstruction, foreign bodies, and pleural disease

Urinary obstruction caused by stricture, stone, or prostatic enlargement

Surgical infections of the skin, muscles, bones, and joints

Sources: McConkey 2002; Ohene-Yeboah 2006; WHO 2003; and personal experiences of the authors in six hospitals in South Asia and Sub-Saharan Africa.

Less commonly, the lower end of the large intestine can spontaneously twist on itself (sigmoid volvulus), producing an obstructed bowel. In late cases, the twisted intestine can cut off its own blood supply, leading to gangrene and requiring resection and repair. The probability of gangrene cannot be predicted, and early surgery must be the rule. In complicated cases in which no qualified surgeon is available, simple procedures like colostomy (transferring the dead intestine outside of the abdomen by creating a usually temporary artificial anus, without reconstruction of the intestine) will resolve the acute problem, so that patients can be referred for a second operation that restores normal function. An uncomplicated sigmoid volvulus can be untwisted without opening the abdomen, by gently inserting a well-lubricated large rubber tube through an instrument (a proctoscope) inserted into the rectum. Overall survival should exceed 80 percent (Mnguni and others 2012; Nuhu and Jah 2010).

Two conditions in children are common causes of intestinal obstruction:

- Heavy infestation with *Ascaris* worms can lead to balls of living worms large enough to obstruct the lumen. In about 80 percent of cases, this condition will resolve spontaneously if the intestine is decompressed with a stomach tube. If an operation is needed, the worms can be removed through a small incision; in rare cases,

the segment of intestine containing the worm ball may have to be removed. Overall mortality should be 1 percent to 2 percent (Wani and others 2010).

- Less commonly, usually in infants under age one, a segment of intestine can invaginate on itself (intussusception), leading to obstruction. This condition can occur spontaneously and is a relatively rare complication of the rotavirus vaccine immunization. In a hospital with a fairly sophisticated radiologist, it will be treated with a moderately high pressure enema, using a dye that can be seen on a fluoroscope as the pressure reduces the invagination. If the skills and equipment for this are not available, the invagination can be relieved by an operation. The procedure is to push on the invaginated segment, never to pull on the distal end. Removal of the invaginated segment is rarely needed. Overall mortality in infants should be 1 percent to 2 percent or less, given early treatment and competent management of anesthesia and fluid replacement. Because of inexperience in infant surgery in many first-level hospitals in LMICs most patients are referred, but referrals can delay treatment and increase mortality (Jiang and others 2013; Ngendahayo and others 2014).

Pelvic Infections with Abscesses. Sexually acquired infections of the fallopian tubes and adjacent organs are common and can usually be successfully treated with antibiotics and without surgery. If an abscess forms and does not respond to medication, simple drainage is usually adequate. In early cases, a trial of antibiotic treatment is the best course; exploratory laparotomy may be necessary for severe, nonresponsive cases. Overall survival should exceed 95 percent. When antibiotic treatment is late or inadequate, death is rare, but infertility and recurrent pelvic pain can ensue, as well as increased incidence of subsequent ectopic pregnancy (Soper 2010).

Peptic Ulcer Complications. Three major advances have reduced the incidence of and mortality rates for peptic ulcers: the discovery that *Helicobacter*, which can be treated with antibiotics, is a primary cause of ulcers; the development of powerful acid-reducing drugs; and the successful endoscopic control of bleeding from ulcers.

Helicobacter infection is widespread and difficult to prevent, and ulcerogenic medicines like nonsteroidal anti-inflammatory drugs (NSAIDs) are widely available and overused, with and without prescription.

Perforation of a peptic ulcer allows a flood of gastric juice to flow into the peritoneal cavity, resulting in diffuse peritonitis that is almost always fatal if untreated. Surgery within 24 hours, with closure of the perforation and washout of the abdominal cavity, is simple and is almost always successful; if followed by appropriate anti-ulcer medical treatment, it leads to a permanent cure for 95 percent of patients. Delayed operations carry higher risks, with a possibility of subsequent abscesses. Overall, 80 percent to 90 percent of patients are likely to survive (Chalya and others 2011; Ugochukwu and others 2013).

Bleeding ulcers pose more serious problems. Severe bleeding requires surgery, transfusions, and skilled anesthetic support, which are often unavailable in smaller hospitals. The old standard operation of pyloroplasty, suture of the bleeding blood vessel, and vagotomy (cutting the vagus nerve that stimulates acid production) is effective; 90 percent of patients will survive, but usually only a fully qualified surgeon will be able to perform the procedure. If possible, these patients should be transferred. If they can go to a third-level center that offers endoscopy services, it is likely that they can be successfully treated without surgery (Simon and others 2013). Younger patients with less than massive bleeding can usually be managed conservatively and transferred, if necessary, after the bleeding has stopped.

Bleeding from Esophageal Varices. In HICs, varicose veins at the lower end of the esophagus are usually complications of alcoholic cirrhosis of the liver. In many LMICs, they are commonly due to a scarred liver caused by *Schistosoma* infestation. The difference is that liver function is very poor in alcoholic cirrhosis patients but is relatively good in patients with varices due to schistosomiasis. When varices from any cause bleed, they almost always bleed massively, requiring multiple transfusions. Alcoholic cirrhosis patients do not do well with operations for varices, but those with schistosomiasis survive and do well with operations and with endoscopic treatments. However, the operations are major undertakings, and the endoscopic treatment requires expensive equipment and skilled personnel. This option is increasingly available in third-level hospitals; these patients are rarely seen in first- or second-level hospitals, probably because they so often die before they reach any hospital.

Perforated Typhoid Ulcers. Perforation is a very serious complication of advanced typhoid infection that causes ulcers of the small intestine. Ulcers can also erode blood vessels to produce major bleeding. Diagnosis of perforation is often late, even when it occurs in hospitalized patients. These ulcers develop in approximately 5 percent of hospitalized patients, and almost always in patients whose antibiotic treatment started late or had not yet become effective (Chalya and others 2012).

Perforated typhoid ulcer 40 years ago was considered to have a hopeless outcome. It is gratifying that several recent reports from Sub-Saharan African

hospitals indicate survival rates of 80 percent to 90 percent after operative repair of a typhoid perforation (Chalya and others 2012; Mock and others 1995; Nasir, Abdur-Rahman, and Adeniran 2011).

Amebic Liver Abscess. Amebic liver abscess responds so well to antibiotics that it rarely needs surgical treatment, but surgeons are usually called to examine these patients and so must understand the proper diagnosis and treatment. The diagnosis is straightforward if ultrasound or computed tomography (CT) scan is available, but this equipment is usually not available in hospitals below the third level.

A trial of antibiotics can be a simple way to resolve the question. If pain and fever persist, indicating that rupture into the abdomen is imminent, the best approach is needle drainage or percutaneous catheter drainage, in combination with antibiotics. In the absence of ultrasound or other localization, surgery may be necessary to ensure proper placement of drainage.

The rupture of such an abscess through the diaphragm and into the pleural space requires urgent surgical intervention. Simple insertion of a large-bore chest tube, combined with appropriate antibiotics, is almost always sufficient.

In low-income countries (LICs), amebic abscesses are more common; in middle-income countries (MICs) and HICs, about 50 percent of the cases of liver abscess are bacterial, requiring intensive antibiotics and drainage (Conter and others 1986). Untreated amebic liver abscesses are often fatal, but even in complicated cases, 95 percent survival can be expected with appropriate treatment (Chavez-Tapia and others 2009; Jha and others 2012).

Gall Bladder and Bile Duct Disease. Acute inflammation of the gall bladder (acute cholecystitis) is very rare in rural parts of LICs but increasingly common in cities and MICs. Experienced surgeons treat most patients with antibiotics and prompt removal of the gall bladder, but antibiotics alone will control infection temporarily so that an operation can be done later. First-level hospitals choose the second option unless they have a fully trained surgeon on staff. Patients with jaundice caused by gallstones passing into and obstructing the common bile duct are referred.

Respiratory Obstructions, Foreign Bodies, and Pleural Disease

Obstruction has many causes, including head and neck infections, bleeding, trauma, tumors, improper positioning of an unconscious person and aspiration. A simple change of position, with or without the insertion of an oral airway or a tube into the trachea, may resolve the problem; often, an incision in the neck is needed to perform cricothyroidotomy or tracheostomy. All surgical staff members should be trained to intubate, perform these simple operations, and correctly position unconscious patients.

Foreign Bodies. If located in the ear, nose, or eye, foreign bodies are usually easy to remove; however, the failure to remove them can result in serious infections. In the larynx and trachea, they can obstruct respiration and cause death. If a foreign body goes beyond the trachea into the bronchial tree, it will produce a pneumonia that is unresponsive to treatment unless the foreign body is removed. The removal of foreign bodies in the bronchi requires referral for bronchoscopy. Swallowed material in the esophagus usually passes through or, if stuck at a high level (the cricopharyngeus), can be extracted with a balloon catheter.

Pneumothorax, Hemothorax, and Empyema. Pneumothorax, hemothorax, and empyema are collections of, respectively, air, blood, or pus in the pleural space that compresses the lungs, leading to respiratory insufficiency; they often produce scarring with permanent disability. Infected fluid is serious and can lead to death. In almost all cases, early drainage with a chest tube, combined with antibiotics as needed, resolves the problem. This simple procedure is easily learned (King and others 1986; WHO 2003).

Urinary Obstructions

Infection can cause scarring of the urethra, stones in the bladder can obstruct the outlet, and an enlarged prostate gland can compress the urethra. In any of these cases, the urethra can be blocked, making urination impossible. Often, an instrument can be passed through the obstruction, followed by a rubber catheter, to relieve the acute problem. However, because the obstruction often recurs, subsequent referral may be needed to remove the prostate or the stone or to more radically dilate the urethra. If the urethra cannot be dilated, a bladder catheter can be inserted above the pubic bone (suprapubic cystostomy) as an emergency procedure. Removal of bladder stones and cystostomy are practical operations at a first-level hospital, and prostatectomy can be performed there, if the skills are available. Stones can also form in the kidney itself. Small ones will pass without surgical treatment; if they do not pass, referral is necessary.

Infections of the Skin, Muscles, Bones, and Joints

Antibiotics have changed the course of infections of the skin, muscles, bones, and joints, which are often associated with bloodstream infections and were important causes of death and disability before the availability of antibiotics. In HICs, serious infections are often treated with aspiration of pus, culturing, and intensive use of antibiotics. In most LMICs, however, access to bacterial culturing is not available; antibiotic choice is limited by availability and cost; and long-term, high-dose antibiotic treatment is impractical.

Fortunately, early treatment with incision and drainage, in combination with a regimen of antibiotics for one to two weeks, is generally successful in locations with limited resources. In late-presenting cases, deaths from sepsis are usually preventable, but bone and joint infections, in particular, can require long-term treatment and subsequent surgery. Because acute infections are common, often occur in children, and do not require complicated surgery, this treatment option is an important and very cost-effective part of the work of a first-level hospital (King and others 1986; WHO 2003). Surgical infections are covered in more detail in chapter 3.

Other General Surgical Emergencies

Although this list of emergency conditions is not exhaustive, it covers at least 95 percent of the emergency problems faced in first- and second-level hospitals. Staff members who treat these patients must be prepared to deal with the common problems, including the traumatic and obstetric emergencies discussed in chapters 3 and 5. Facilities should be equipped and supplied to support this treatment. Referral is necessary for less common and more complicated conditions, but it should be kept to a minimum because of the weakness of existing referral systems.

Certain other surgical emergencies common in HICs but not in LMICs are not discussed in this chapter—notably, diverticulitis, intestinal obstruction or perforation resulting from colon cancer, and complications of arteriosclerosis (such as ruptured abdominal aortic aneurism and gangrene of extremities). These conditions will undoubtedly become more important as LMICs progress through the epidemiological transition, in which the complications of a western diet, arteriosclerosis, and cancer increase. Planners in LMICs must be aware of these changes in the disease spectrum, which will increase the cost and reduce the potential benefits of surgical treatment in the future (Stewart and others 2014).

Congenital surgical emergencies are covered in detail in chapter 8. Some of these, especially pyloric stenosis and colostomy for imperforate anus, are completely within the competence of a well-trained general surgeon in a first- or second-level hospital, although it is rare to find a general surgeon who does these operations.

Almost all of the conditions listed in box 4.1 can be treated in first-level hospitals (see table 4.1), although many of these facilities would refer most or all of these patients to a higher level. The public quickly comes to know if referral is likely and learns to bypass the closer hospital and go directly to a larger center. If bypassing is not possible, patients simply stay home. Patients often do not reach the higher-level hospitals to which they are referred, usually for economic reasons (Urassa and others 2005). The important factor limiting the capacity of first-level hospitals is training (Abdullah and others 2011). The shortage of qualified surgeons and anesthetists can be corrected in the short term by training general practitioners, nonphysician clinicians, and nurses to care for most of the common conditions; in the long term, the shortage can be corrected by training appropriate specialists. Approaches to these options are discussed briefly in this chapter and in more detail in chapters 12 and 17.

DISEASE BURDEN OF GENERAL SURGICAL EMERGENCIES

The World Health Organization's (WHO's) Global Health Estimates report global disability-adjusted life years (DALYs) lost from 163 specified disease causes (WHO 2013a); DALYs are a measure of the years of life lost or seriously impaired by disease, both overall and from specified disease entities.

The Global Health Estimates do not specifically identify general surgical emergencies, but by combining the estimates for three categories (peptic ulcer disease, appendicitis, other digestive diseases) out of the 163, in which death or disability usually results from a general surgical emergency, an estimate of the worldwide rate of DALYs lost from these conditions can be created. At 596 per 100,000 population, this constitutes 1.5 percent of DALYs from all causes, in all parts of the world (table 4.3). The estimates for injuries, maternal, neonatal, and three general surgical emergencies in LMICs were considerably higher than those in HICs.

Diagnoses for cause of death in LMICs are usually rough estimates, especially for the acute abdominal conditions lumped together under *other digestive diseases*.

Not included because they were not listed separately in this DALY calculation are respiratory obstruction, pneumothorax, and surgical infections (including empyema, osteomyelitis, abscesses, pelvic infections, and perforated typhoid ulcers).

Debas and others (2006) do not consider general surgical emergencies separately, but they estimate that 11 percent of all lost DALYs worldwide were due to surgically correctable conditions. They make it clear that this is a very rough estimate, based on "best guesses" by 18 surgical experts of the percentage of patients who could be successfully treated within a list of conditions considered surgically treatable. These estimates were then applied to the DALY numbers provided by WHO (2002) for each category of potential surgical conditions; the estimates are based on hospital experiences, not on population surveys.

Vital registers are inaccurate or nonexistent in almost all LMICs. Only three population-based surveys have tried to estimate the incidence and mortality rates from all surgical emergencies, using family members' recall of disease and death. One set of surveys, conducted in a remote, mountainous part of Pakistan, found death rates from nontraumatic surgical emergencies to be only moderately higher than in the United States in 1935: 55 and 61 per 100,000, respectively, depending on the sample surveyed (Ahmed and others 1999). The other two surveys, from rural parts of Sierra Leone and Rwanda, calculated much higher death rates for acute abdominal emergencies (825 per 100,000 per year for acute abdominal conditions), but the surveys probably encountered problems with the recall method. In one, the surveyors calculated a total (all diagnoses) crude death rate of 59.7 per 1,000, which is more than three times the total crude death rate estimated for Sub-Saharan Africa by WHO (Groen and others 2012; Petroze and others 2013).

Compiling these data can yield a rough estimate of the disease burden from general surgical emergencies in LMICs, from 1 percent to 3 percent of all deaths and all DALYs—more than 10 percent of all surgical DALYs. At that rate, these conditions are not unimportant, and several factors combine to make them even more so:

- Reasonably early treatment will achieve good results, usually with complete cures.
- Without treatment, mortality rates are high.
- All of the general surgical emergencies are common in children and young adults.
- Human and other resources needed for effective treatment are the same as those needed to treat the other important surgically treatable conditions, including trauma and maternal and perinatal mortality.

EFFECTIVENESS OF SURGICAL TREATMENT

In Germany in 1926, when surgery for acute peritonitis was considered contraindicated, Kirschner (1926) reported a peritonitis hospital mortality rate of 85 percent. Although established peritonitis is still a serious condition, mortality rates of less than 10 percent would be expected today in LMICs, with appropriate surgery combined with intravenous fluids and antibiotics. If surgery can be performed within 24 hours of disease onset, mortality should be much lower than 10 percent.

Meta-analysis of all available operative mortality statistics worldwide has shown that the overall decline in mortality has been slower in LMICs than in HICs (Bainbridge and others 2012). The problems that have led to this slower rate clearly need to be addressed, but the progress that has been achieved in perioperative mortality is not inconsiderable and seems to be increasing. Comparing 1970–90 with 1990–2010, the same meta-analysis shows a decline in perioperative mortality in LMICs from 0.73 percent in the first 20-year period to 0.25 percent in the second period.

The overall survival rates of higher than 95 percent cited for most of the four common categories of emergencies in table 4.2 are based on reports from hospitals in LICs, primarily in Sub-Saharan Africa. These results have been achieved despite the late arrival of many patients and the high prevalence of comorbid conditions, such as malaria and HIV infection. Médecins Sans Frontières reported on 16,377 major operations in LMICs, most performed for emergencies in the very basic, first-level hospitals they operated, with a hospital mortality rate of 0.2 percent (Chu, Ford, and Trelles 2010). Staff without formal surgical training performed many of these operations, but trained surgeons were almost always available for consultation and assistance. A report of 1,976

Table 4.2 Global DALYs, by Cause, 2011
per 100,000 population

Disease	DALYs	Percent
All causes	39,553	100.0
AIDS and tuberculosis	1,372	3.5
Cardiovascular disease	5,461	13.8
Injuries	4,278	10.8
Maternal	273	0.7
Neonatal	3,338	8.4
General surgical emergencies[a]	596	1.5

Source: WHO 2013a.
Note: DALYs = disability-adjusted life years.
a. Peptic ulcer disease, appendicitis, other digestive diseases.

operations for acute abdominal conditions in a Sub-Saharan African public hospital finds a hospital mortality rate of less than 10 percent (Ohene-Yeboah 2006). A small Sub-Saharan African hospital with no trained surgeon on staff and very limited capacity for referral reports a hospital mortality rate of 10 percent for 173 patients with acute abdominal emergencies (McConkey 2002). The operations were performed by general practitioners.

In most cases, if patients are discharged alive, they are discharged cured and will need no further treatment. Exceptions occur, with late problems requiring additional treatment in fewer than 10 percent of cases.

COST OF SURGICAL TREATMENT

Calculating the cost of individual surgical procedures in any setting involves multiple assumptions. The calculation becomes even more complicated in LMICs, where hospitals have multiple sources of income, including gifts in kind; records are poor; and corruption is commonplace. The overall cost per admission or procedure varies greatly between first- and third-level hospitals; third-level hospitals are much more expensive (see chapter 12).

Within regional income classifications, there is considerable variation between regions in per patient hospital expenditure. Latin American countries generally spend more, but even there the costs of major surgical procedures are very low, especially in first-level hospitals. One review compares the recurrent cost per major operation in six district hospitals in Mozambique, Tanzania, and Uganda, all three LICs. Results indicate that the cost per operation was US$42–US$98 in five of the six. At one low-volume Ugandan hospital, the cost was US$308 per operation (Kruk and others 2010). If these low-cost estimates were grouped with other estimates of DALYs averted by emergency operations (nine per general surgical operation in box 4.2), the cost per DALY would be very low indeed.

The calculation of the marginal cost-benefit of a particular operation is clearly not the first consideration for health policy makers and planners in LMICs. Political considerations will—and should—nearly always lead them to construct general first- and second-level hospitals that have the ability to manage or refer all emergency conditions, whether surgical, medical, or pediatric. The questions for policy makers and planners are how much the total cost of such facilities will be; what populations they can serve; what services will be most or least cost-effective; and what conditions, if any, can be referred.

The cost and effectiveness of first-level hospitals, the systems to support them, and the role of surgery within

Box 4.2

DALYs Averted by Kind of Surgery at Gonoshasthaya Kendra Hospital, Bangladesh, 1995

Table B4.2.1 reports the estimated DALYs averted by surgical treatment in a 50-bed hospital in Bangladesh. In the three-month period studied, 154 operations were performed; 80 percent were emergencies. A qualified surgeon and an obstetrician were available for most of these procedures. Anesthesia was provided by a locally trained paramedic with no formal hospital training. All nurses and operating room staff were locally trained without formal qualifications. One obstetric death and one general surgical operative death occurred. All other patients were discharged well. There were no referrals.

DALY estimates were based on local experience and are believed to be conservative, for example, acute appendicitis was considered to have a 10 percent risk of a fatal outcome without surgery if there was no perforation or gangrene; the risk estimate rose to 95 percent if perforation and peritonitis had occurred.

The list of operations is typical for small, first-level hospitals in LICs with trained specialists available.

- 27 percent of operations were general surgical; almost all of these were emergencies.
- 15 percent of DALYs averted came from general surgical emergencies.
- The hospital was rural but adjacent to a major highway. The relatively small number of trauma cases reflects the absence of any referral system to bring injured patients to the hospital.

box continues next page

Box 4.2 (continued)

Table B4.2.1 DALYs Averted in Three Months, First-Level Hospital, Bangladesh, 1995

	Number of operations	Total DALYs averted	DALYs averted per operation
Obstetrics and gynecology			
Cesarean section	40	1,588	40
Dilation and curettage	24	44	2
Ectopic pregnancy	2	72	36
Extraction of placenta	4	26	7
Cervical tear	1	3	3
Other gynecological	20	149	7
All obstetrics and gynecology	91	1,882	21
General surgery			
Appendectomy	10	49	5
Cancer	1	13	13
Gall bladder	4	30	8
Hernia	6	47	8
Other acute abdomen	4	64	16
Chest (tube drainage)	3	76	25
Incision and drainage of infection	13	91	7
All general surgery	41	370	9
Trauma			
Closed fractures	11	43	4
Major wounds and compound fractures	6	81	14
Burns	5	53	11
All trauma	22	177	8
All surgical procedures	154	2,429	16

Source: Data from McCord and Chowdhury 2003.
Note: DALY = disabilty-adjusted life year.

them is discussed in chapters 12, 18, and 19. First-level hospitals have been shown to best serve the needs of the population and to be cost-effective. Their surgical services are usually the most effective component (Debas and others 2006; Gosselin, Thind, and Bellardinelli 2006; McCord and Chowdhury 2003). At first-level facilities, the same staff can provide services for most general surgical, obstetric, and trauma emergencies. With minor adjustments, the same structure, equipment, and supplies can serve all three components at very low cost. At higher referral levels, increasingly specialized services combined with other inefficiencies can increase costs enormously.

BASIC SYSTEMS FOR SURGICAL EMERGENCIES

Although several types of operations can be done in less-than-ideal conditions, the availability of basic facilities and supporting systems makes procedures simpler, safer, and more efficient. Controlling cost and making optimal use of resources are important everywhere, especially in LMICs. Hence, it is essential to define the basic needs for a functioning surgical system. Fortunately, these essentials do not need to be expensive. Some hospitals in LMICs provide good, lifesaving service for a total cost of less than US$50

per patient day, compared with more than US$1,000 per patient day for hospitals in HICs (Kruk and others 2010). A well-equipped operating theater can be created in LMICs for less than the cost of a small diner or restaurant in a HIC.

Almost all of the surgical emergencies listed in table 4.2 can be managed successfully in a first-level hospital, but the basic elements must be in place:

- *Functioning hospital:* The hospital should have wards, an outpatient area, a receiving area for emergency patients, a pharmacy, and a laboratory. Ideally, the hospital would also have a blood bank and adequate staff quarters. Usually, these small facilities will have 50–250 beds.
- *Operating room:* The operating room should have appropriate surgical and anesthetic equipment and supplies.
- *Capacity to administer anesthesia:* It is important for first-level hospitals to have the capability to administer anesthesia (see chapter 15). Most general surgical emergencies can be managed with local, spinal, or ketamine anesthesia, but some require general anesthesia, with induced paralysis and tracheal intubation.
- *Resuscitation:* Many of the most severe emergency patients arrive at hospitals unconscious, in shock, with respiratory obstructions or other urgent problems that must be resolved before surgical treatment can be considered. The essentials of resuscitation are not complicated and are usually very effective: managing the airway, controlling bleeding, and providing adequate fluid replacement. Blood for transfusion can be useful but usually is not essential. Resuscitation, which is often not managed well, is one of the most important training needs in the hospital systems of LMICs. Staff members at all levels should be trained and equipped to provide this service, and areas should be set aside where equipment and trained staff are available (see chapters 14 and 15).
- *Supplies:* Adequate quantities of basic supplies are essential; in addition to gauze and linen, intravenous fluids and antibiotics are the most important. Complicated intravenous fluid preparations are not essential, but the basic dextrose with water and dextrose with saline must be available, along with the means to add potassium when needed. Appropriate use of high-dose antibiotics can be lifesaving in cases with established infections that require adequate drainage and debridement. Prophylactic antibiotics can be useful when there has been contamination without established infection (as in an operation requiring the opening of the intestine) but should not be continued beyond 24 hours. Almost all patients can be managed with inexpensive, long-established antibiotics. Guidelines for the appropriate use of antibiotics should be available at all levels. WHO's essential medicine list can be a basis for these guidelines (WHO 2013b).
- *Referral system:* A referral system, with health centers that refer, as well as larger hospitals that receive more complicated cases, should complement the hospital. This model requires some sort of transport system to move patients between these units.

Most countries have second-level facilities with fully trained surgeons. Budgetary, staffing, and transport constraints usually require that all hospitals, including at the second and third levels, have a first-level function for the local geographic area.

Training and Distribution of Staff Members

Training. Effective training programs for staff members are essential. It is not realistic to expect that all surgical staff will be fully qualified specialists or certified operating room nurses; general practitioners, nonphysician clinicians, and nurses can be trained to manage most of the surgical emergencies seen in first-level hospitals. Variation in surgical capability is an important factor that can limit the number of general surgical emergencies treated, as well as the quality of the outcomes.

Because first-level facilities need to perform emergency obstetrical and trauma surgery, training programs should create the capacity to manage all three categories of surgical emergencies: general surgical, traumatic, and obstetric. Programs in Sub-Saharan Africa and elsewhere have demonstrated that training can be done at low cost and without stationing qualified specialists at every location (Mkandawire, Ngulube, and Lavy 2008; Nyamtema and others 2011; Sani and others 2009; van Amelsfoort and others 2010).

Surgical societies, such as the West African College of Surgeons and the College of Surgeons of East, Central, and Southern Africa, have developed training and education programs for surgeons in most LMICs; these programs are modeled on the programs of similar societies in HICs. Most LMICs have a nucleus of well-trained surgical specialists; in some countries, large numbers of trained specialists are available. To date, qualified specialists and surgical societies have not had an important role in the training and supervision of those who perform surgery in the smaller, first-level hospitals. If these surgical societies could take a major interest in the creation of the surgical networks and in monitoring performance, surgical care in LMICs would be significantly improved.

Distribution. The effective distribution of skilled personnel is an additional challenge. All LMICs have difficulty inducing qualified medical personnel to work outside of major cities, largely because private patients are few and public facilities that serve poor people pay low salaries.

Most LMICs partially resolve this problem by sending recent medical graduates to staff first-level hospitals (general practitioner surgeons), training nurses or other staff to administer anesthesia, and staffing operating rooms with nurses or others without special training. A few countries have trained nonphysician clinicians to perform surgery (see chapters 17 and 19). Because 90 percent or more of the essential operations are within the potential competence of a general practitioner or nonphysician clinician surgeon with a nonphysician anesthetist, short-course training before assignment and periodic skills improvement courses can greatly improve the quantity and the quality of surgical treatment in these places. Regular visits by supervising specialists will serve to maintain and expand the skills, as well as to evaluate quality through audits. Regular supervision of this sort is extremely rare in LMICs.

The shortage of trained staff members results in costly inefficiency in facilities that are working at less than capacity (Kruk and others 2010). Many very poor countries are only beginning to train doctors to qualify as surgeons and anesthetists. General practitioner and nonphysician clinician surgeons in first-level hospitals usually become competent at managing obstetrical emergencies with nurse-midwives and nurse-anesthetists. However, they are less confident with general surgical emergencies and trauma, so that these patients are often referred. Because of financial and other barriers, this practice often means that the patients do not receive the treatment they need (Cannoodt, Mock, and Bucagu 2012; Grimes and others 2011).

Training programs, supply systems, and supervision should be designed to create and maintain the necessary capacity at each level and to facilitate transfers between facilities as much as is practical.

General Surgical Procedures in an Ideal System

Table 4.3 presents a list of procedures that should be available at different levels of the hospital system. For this system to function well, efficient patient transfers in and out are important. However, the realities of available transportation options, as well as the financial and other barriers faced by transferred patients and their families, make it essential to reduce the need for transfers; common conditions must be managed locally to the extent possible. This need to diffuse services to smaller units may change as more specialists are trained, transportation improves, and economic growth increases the purchasing power of the population. But in most LICs for the next generation or more, most people will be treated in public hospitals. General practitioner or nonphysician clinician surgeons will provide much, if not most, of the surgical services available, and they will work in small, first-level facilities, serving populations from 50,000 to 250,000. Larger urban hospitals also need to provide first-level services in many cases; ideally, to avoid congestion in facilities that often serve several million people, networks of district first-level hospitals would be established even in cities.

NEW TECHNOLOGY

Two trends in the revolution in operative surgery in the past decade are particularly noteworthy. First is a general move to more conservative procedures to treat infections, malignancies, and biliary, vascular, and other diseases. Second, innovation and new technologies have facilitated this conservative trend. The intensive use of potent antibiotics has reduced the need for surgery. Video-assisted surgery and stapled suturing have simplified surgical techniques. Ultrasound, computerized radiographic technology, magnetic resonance imaging, and endoscopy have improved preoperative diagnoses; in some cases, they have eliminated the need for surgery.

Some of these advances, however, are very expensive; all of them increase the demand for technical expertise to operate and maintain the new equipment. Surgeons, policy makers, and planners should keep in mind that most of the improvements in surgical outcomes since the 1930s occurred before 1950, before any of these new techniques had been developed and become available.

It is important to address three limitations on the use of new technologies in the context of the limited budgetary and human resources in LMICs:

- *Cost:* Both the initial costs and the costs of maintenance and service should be reasonable.
- *Trained personnel:* Trained personnel should be available to perform the procedures, train assistants, and ensure that the equipment is adequately serviced and well maintained.
- *Disposable parts and supplies:* Parts and supplies are usually expensive, and they put an additional burden

Table 4.3 General Surgical Emergency Capacity in an Ideal System

Capacity	Health center	First-level hospitals with general practitioner surgeon or nonphysician clinician	First- or second-level hospitals with qualified surgeon	Third-level hospitals
Airway management, fluid replacement, bleeding control, antibiotics	X[a]	X	X	X
Blood transfusion		X[a]	X	X
Tube thoracostomy		X[a]	X	X
Tracheal tube		X[a]	X	X
Local anesthesia	X	X	X	X
Spinal and general anesthesia		X	X	X
Hernia and intestinal obstruction		X[a]	X	X
Appendicitis		X	X	X
Perforated peptic ulcer		X[a]	X	X
Bleeding peptic ulcer			X	X
Bleeding esophageal varices				X
Pelvic peritonitis		X	X	X
Perforated typhoid ulcer		X[a]	X	X
Colostomy		X[a]	X	X
Cystostomy		X[a]	X	X
Cricothyroidostomy		X[a]	X	X
Foreign body removal		X	X	X
Damage-control laparotomy[b]		X[a]	X[a]	X

a. Capacity (i.e., trained staff available 24 hours, with adequate equipment and supplies) should be there, but usually is not.
b. This procedure is usually a way to deal with severe trauma, but could be a way to deal with the intestine in a very sick patient, when intestine must be removed, but it is not possible to restore continuity by sewing the ends back together. The ends can simply be tied off and the patient referred for another operation.

on supply systems that are sometimes nonexistent and always under strain.

It may be possible to overcome these conditions in regional hospitals and in the major referral centers, but they are important barriers to the use of new technology in first- and second-level hospitals. Virtually no data are available to enable cost-effectiveness analysis.

Examples illustrating some of the complexities introduced by technical advances include the following:

- *Appendicitis* that has not progressed to perforation, abscess, gangrene, or generalized peritonitis can be successfully treated with high-dose, intensive antibiotics, but the condition will recur in 10 percent to 20 percent of patients who are treated without operation. Randomized controlled trials of antibiotic treatment for nonperforated, nongangrenous appendicitis are underway in HICs (Mason and others 2012); even if these trials favor nonsurgical treatment, they depend on a definitive determination that perforation or other complications have not occurred, which requires a CT scan. In LMICs, CT scanners generally are not available at first- or second-level hospitals and are only beginning to be introduced in third-level hospitals. Nonsurgical treatment of appendicitis is not likely to be practical for most people in LICs in the foreseeable future.
- *Bleeding peptic ulcer* can almost always be controlled without surgery using endoscopy. In one Indian hospital where mortality was very low, only 3 percent of patients required operations (Simon and others 2013). However, endoscopes and the skill to use them are rarely available at first-level hospitals, and the surgery to control a bleeding ulcer is considerably more complicated than that for an appendectomy. These patients should be referred, if possible.

One technological advance that can easily be made available in all hospital operating rooms is pulse oximetry.

The pulse oximeter, a simple, sturdy, and inexpensive device that continuously monitors oxygen levels in the blood, has increased the safety of general anesthesia. WHO has launched the Patient Safety Pulse Oximetry project to improve the safety of surgical anesthesia care in LMICs, testing the effect on patient outcome of providing a bundle consisting of the Surgical Safety Checklist, pulse oximeters, and training in a number of pilot hospitals globally. WHO, with the World Federation of Societies of Anaesthesiologists, the Association of Anaesthetists of Great Britain and Ireland, and others, has developed a training tool kit consisting of a manual, a video, and slide sets to improve provider responses to hypoxemia.

The results of "old-fashioned" surgery are generally comparable to those obtained with modern technology, so health policy makers and planners in LMICs may want to devote resources to other priorities. The first priority should be to provide the basic services that are the most cost-effective. Unfortunately, those patients who can pay often demand high technology, even in the poorest countries, which can influence the planning process. There is a real risk that basic surgery in first- and second-level hospitals will be considered second class and that qualified surgeons in private practice will encourage that opinion. That mindset needs to be avoided, or it could set back progress considerably.

BARRIERS TO EFFECTIVE SERVICE DELIVERY

Hospital and community surveys in LICs show that the proportion of patients with surgical emergencies who receive effective treatment is very low (Ahmed and others 1999; Grimes and others 2011; Kruk and others 2010; Mock and others 1998) and that many of those who are untreated die. Multiple barriers to delivery of surgical services exist in these countries. By far the most important are inadequate training of existing staff, lack of a referral system that can bring patients to referral hospitals from health centers and dispensaries, and the financial burden of a hospital stay for poor families (see chapter 12).

The financial burden for patients and families is very important. Even when services are free, a major operation can create a debt burden from which a family may not recover (Afsana 2004). Lost income; travel and maintenance costs for patients and those who accompany them; food, medications, and supplies not available in the hospital; and "informal charges" to obtain minimal services can add up to large sums. This reality is an important reason to avoid referrals as much as possible.

FUTURE DIRECTIONS

Research has underscored the magnitude of the burden of surgical disease in LMICs and the extent of the unmet need for surgical care. Although the estimates available are imprecise, most LMICs clearly have a substantial burden of surgically treatable disease, and the available surgical treatments reach only a fraction of the population in need. It is also clear that the needed services can be provided at remarkably low cost and that surgery in very simple settings can be effective.

- The urgent need today is to know more about the cost and cost-effectiveness of programs to expand services as well as to improve training, supervision, logistical support, and the referral system. This knowledge will be best acquired in the context of active programs to increase coverage, improve service delivery, and provide better support for service delivery in existing facilities, especially first-level hospitals.
- The standards for training and certification of all staff members providing surgical care need to be developed. These standards and certifications include specialists, but also general practitioner surgeons, nonphysician clinician surgeons, anesthetists, and operating theater staff.
- Monitored guidelines and checklists to organize and supervise treatment are needed. The active involvement of national and regional professional associations in these programs and investigations is essential.
- Monitoring and evaluating progress requires hospitals that provide surgical services to have databases. The databases need to be improved, but this improvement must acknowledge that too much paperwork can detract from service delivery. Nursing staff, in particular, already have a heavy recordkeeping burden. Improvements should be designed to reduce this burden, improve quality, and ensure that the data collected are used to improve service.

With commitment by the surgical leadership, progress could be rapid in coming years. The number of qualified surgeons and anesthetists in the poorest countries is growing exponentially, and ways can be found to persuade them to locate in or near first-level hospitals. In the interim, most of these conditions can be treated with relatively simple surgery, which means that general practitioners, nonphysician clinicians, and nurses can upgrade their skills with relatively short training aimed at those who will be assigned to first-level hospitals. Ideally, this training will be conducted in larger, high-volume hospitals by qualified surgeons who will follow up with in-service training and supervision conducted in the

first-level hospitals where these short-course surgeons practice. Models exist for this sort of upgrading program in Malawi, Niger, and Tanzania (Mkandawire, Ngulube, and Lavy 2008; Nyamtema and others 2011; Sani and others 2009; van Amelsfoort and others 2010).

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

REFERENCES

Abdullah, F., S. Choo, A. A. Hesse, F. Abantanga, E. Sory, and others. 2011. "Assessment of Surgical and Obstetrical Care at 10 District Hospitals in Ghana Using On-Site Interviews." *Journal of Surgical Research* 171 (2): 461–66. doi:10.1016/j.jss.2010.04.016.

Adesunkanmi, A. R., and E. A. Agbakwuru. 1996. "Changing Pattern of Acute Intestinal Obstruction in a Tropical African Population." *East African Medical Journal* 73 (11): 727–31.

Afsana, K. 2004. "The Tremendous Cost of Seeking Hospital Obstetric Care in Bangladesh." *Reproductive Health Matters* 12 (24): 171–80.

Ahmed, M., M. Shah, S. Luby, P. Drago-Johnson, and S. Wali. 1999. "Survey of Surgical Emergencies in a Rural Population in the Northern Areas of Pakistan." *Tropical Medicine and International Health* 4 (12): 846–57.

Bainbridge, D., J. Martin, M. Arango, and D. Cheng. 2012. "Perioperative and Anaesthetic-Related Mortality in Developed and Developing Countries: A Systematic Review and Meta-Analysis." *The Lancet* 380 (9847): 1075–81. doi:10.1016/s0140-6736(12)60990-8.

Burkitt, D. P., A. R. Walker, and N. S. Painter. 1972. "Effect of Dietary Fibre on Stools and the Transit-Times, and Its Role in the Causation of Disease." *The Lancet* 2 (7792): 1408–12.

Cannoodt, L., C. Mock, and M. Bucagu. 2012. "Identifying Barriers to Emergency Care Services." *International Journal of Health Planning and Management* 27 (2): e104–20. doi:10.1002/hpm.1098.

CDC (Centers for Disease Control). 1990. *Vital Statistics of the United States*, Vol. 2, *Mortality*, Part B. http://www.cdc.gov/nchs/data/vsus/mort90_2b.pdf.

Chalya, P. L., J. B. Mabula, M. Koy, J. B. Kataraihya, H. Jaka, and others. 2012. "Typhoid Intestinal Perforations at a University Teaching Hospital in Northwestern Tanzania: A Surgical Experience of 104 Cases in a Resource-Limited Setting." *World Journal of Emergency Surgery* 7: 4. doi:10.1186/1749-7922-7-4.

Chalya, P. L., J. B. Mabula, M. Koy, M. D. McHembe, H. Jaka, and others. 2011. "Clinical Profile and Outcome of Surgical Treatment of Perforated Peptic Ulcers in Northwestern Tanzania: A Tertiary Hospital Experience." *World Journal of Emergency Surgery* 6: 31. doi:10.1186/1749-7922-6-31.

Chavez-Tapia, N. C., J. Hernandez-Calleros, F. I. Tellez-Avila, A. Torre, and M. Uribe. 2009. "Image-Guided Percutaneous Procedure Plus Metronidazole versus Metronidazole Alone for Uncomplicated Amoebic Liver Abscess." *Cochrane Database of Systematic Reviews* 1: Cd004886. doi:10.1002/14651858.CD004886.pub2.

Chu, K. M., N. Ford, and M. Trelles. 2010. "Operative Mortality in Resource-Limited Settings: The Experience of Médecins Sans Frontiéres in 13 Countries." *Archives of Surgery* 145 (8): 721–25. doi:10.1001/archsurg.2010.137.

Conter, R. L., H. A. Pitt, R. K. Tompkins, and W. P. Longmire Jr. 1986. "Differentiation of Pyogenic from Amebic Hepatic Abscesses." *Surgery, Gynecology, and Obstetrics* 162 (2): 114–20.

Curci, M. 2012. "Task Shifting Overcomes the Limitations of Volunteerism in Developing Nations." *Bulletin of the American College of Surgeons* 97 (10): 9–14.

Debas, H. T., R. Gosselin, C. McCord, and A. Thind. 2006. "Surgery." In *Disease Control Priorities in Developing Countries,* 2nd ed., edited by D. T. Jamison, J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, and P. Musgrove, 1245–59. Washington, DC: World Bank and Oxford University Press.

Grimes, C. E., K. G. Bowman, C. M. Dodgion, and C. B. Lavy. 2011. "Systematic Review of Barriers to Surgical Care in Low-Income and Middle-Income Countries." *World Journal of Surgery* 35 (5): 941–50.

Gosselin, R. A., A. Thind, and A. Bellardinelli. 2006. "Cost/DALY Averted in a Small Hospital in Sierra Leone: What Is the Relative Contribution of Different Services?" *World Journal of Surgery* 30 (4): 505–11. doi:10.1007/s00268-005-0609-5.

Groen, R. S., M. Samai, K. A. Stewart, L. D. Cassidy, T. B. Kamara, and others. 2012. "Untreated Surgical Conditions in Sierra Leone: A Cluster Randomised, Cross-Sectional, Countrywide Survey." *The Lancet* 380 (9847): 1082–87. doi:10.1016/s0140-6736(12)61081-2.

Jamison, D. T., J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, and P. Musgrove, eds. 2006. *Disease Control Priorities in Developing Countries*, 2nd ed. Washington, DC: World Bank and Oxford University Press.

Jha, A. K., G. Das, S. Maitra, T. K. Sengupta, and S. Sen. 2012. "Management of Large Amoebic Liver Abscess—A Comparative Study of Needle Aspiration and

Catheter Drainage." *Journal of the Indian Medical Association* 110 (1): 13–15.

Jiang, J., B. Jiang, U. Parashar, T. Nguyen, J. Bines, and others. 2013. "Childhood Intussusception: A Literature Review." *PLoS One* 8 (7): e68482. doi:10.1371/journal.pone.0068482.

King, M., P. Bewes, J. Cairns, and J. Thornton, eds. 1986. Chapters 5, 6, and 7. In *Non-Trauma.* Vol. 1 of *Primary Surgery*, 52–103. Oxford: Oxford University Press.

Kirschner, M. 1926. "Die behandlung der akutren eitrigen freien Bauchfellentzundung." *Archivus Klinikum Chirurgicum* 142: 253.

Kruk, M. E., A. Wladis, N. Mbembati, S. K. Ndao-Brumblay, R. Y. Hsia, and others. 2010. "Human Resource and Funding Constraints for Essential Surgery in District Hospitals in Africa: A Retrospective Cross-Sectional Survey." *PLoS Med* 7 (3): e1000242. doi:10.1371/journal.pmed.1000242.

Lavy, C., A. Tindall, C. Steinlechner, N. Mkandawire, and S. Chimangeni. 2007. "Surgery in Malawi: A National Survey of Activity in Rural and Urban Hospitals." *Annals of the Royal College of Surgeons of England* 89 (7): 722–24. doi:10.1308/003588407x209329.

Madziga, A. G., and A. I. Nuhu. 2008. "Causes and Treatment Outcome of Mechanical Bowel Obstruction in North Eastern Nigeria." *West African Journal of Medicine* 27 (2): 101–05.

Mason, R. J., A. Moazzez, H. Sohn, and N. Katkhouda. 2012. "Meta-Analysis of Randomized Trials Comparing Antibiotic Therapy with Appendectomy for Acute Uncomplicated (No Abscess or Phlegmon) Appendicitis." *Surgical Infections* (Larchmt) 13 (2): 74–84. doi:10.1089/sur.2011.058.

McConkey, S. J. 2002. "Case Series of Acute Abdominal Surgery in Rural Sierra Leone." *World Journal of Surgery* 26 (4): 509–13. doi:10.1007/s00268-001-0258-2.

McCord, C., and Q. Chowdhury. 2003. "A Cost Effective Small Hospital in Bangladesh: What It Can Mean for Emergency Obstetric Care." *International Journal of Gynaecology and Obstetrics* 81 (1): 83–92.

Mkandawire, N., C. Ngulube, and C. Lavy. 2008. "Orthopaedic Clinical Officer Program in Malawi: A Model for Providing Orthopaedic Care." *Clinical Orthopaedics and Related Research* 466 (10): 2385–91. doi:10.1007/s11999-008-0366-5.

Mnguni, M. N., J. Islam, V. Manzini, V. Govindasamy, B. M. Zulu, and others. 2012. "How Far Has the Pendulum Swung in the Surgical Management of Sigmoid Volvulus? Experience from the KwaZulu-Natal Teaching Hospitals and Review of the Literature." *Colorectal Disease* 14 (12): 1531–37. doi:10.1111/j.1463-1318.2012.03046.x.

Mock, C. N., G. J. Jurkovich, D. nii-Amon-Kotei, C. Arreola-Risa, and R. V. Maier. 1998. "Trauma Mortality Patterns in Three Nations at Different Economic Levels: Implications for Global Trauma System Development." *Journal of Trauma* 44 (5): 804–12; discussion 812–4.

Mock, C. N., L. Visser, D. Denno, and R. Maier. 1995. "Aggressive Fluid Resuscitation and Broad Spectrum Antibiotics Decrease Mortality from Typhoid Ileal Perforation." *Tropical Doctor* 25 (3): 115–17.

Mulligan, J., J. Fox-Rushby, T. Adams, B. Johns, and A. Mills. 2003. "Unit Costs of Health Care Inputs in Low and Middle Income Regions." Working Paper 9, Disease Control Priorities. Fogarty International Center, National Institutes of Health, Bethesda, MD.

Nasir, A. A., L. O. Abdur-Rahman, and J. O. Adeniran. 2011. "Predictor of Mortality in Children with Typhoid Intestinal Perforation in a Tertiary Hospital in Nigeria." *Pediatric Surgery International* 27 (12): 1317–21. doi:10.1007/s00383-011-2924-2.

Ngendahayo, E., A. Bonane, G. Ntakiyiruta, A. Munyanshongore, N. Muganga, and others. 2014. "Preparing for Safety Monitoring after Rotavirus Vaccine Implementation: A Retrospective Review of Intussusception Cases among Children at a Large Teaching Hospital in Rwanda, 2009–2012." *Pediatric Infectious Disease Journal* 33 (Suppl 1): S99–103. doi:10.1097/inf.0000000000000093.

Nilsson, H., G. Stylianidis, M. Haapamaki, E. Nilsson, and P. Nordin. 2007. "Mortality after Groin Hernia Surgery." *Annals of Surgery* 245 (4): 656–60.

Nuhu, A., and A. Jah. 2010. "Acute Sigmoid Volvulus in a West African Population." *West African Journal of Medicine* 29 (2): 109–12.

Nyamtema, A. S., S. K. Pemba, G. Mbaruku, F. D. Rutasha, and J. van Roosmalen. 2011. "Tanzanian Lessons in Using Non-physician Clinicians to Scale up Comprehensive Emergency Obstetric Care in Remote and Rural Areas." *Human Resources for Health* 9: 28. doi:10.1186/1478-4491-9-28.

Ohene-Yeboah, M. 2006. "Acute Surgical Admissions for Abdominal Pain in Adults in Kumasi, Ghana." *ANZ Journal of Surgery* 76 (10): 898–903. doi:10.1111/j.1445-2197.2006.03905.x.

Petroze, R. T., R. S. Groen, F. Niyonkuru, M. Mallory, E. Ntaganda, and others. 2013. "Estimating Operative Disease Prevalence in a Low-Income Country: Results of a Nationwide Population Survey in Rwanda." *Surgery* 153 (4): 457–64. doi:10.1016/j.surg.2012.10.001.

Sani, R., B. Nameoua, A. Yahaya, I. Hassane, R. Adamou, and others. 2009. "The Impact of Launching Surgery at the District Level in Niger." *World Journal of Surgery* 33 (10): 2063–68. doi:10.1007/s00268-009-0160-x.

Shillcutt, S. D., M. G. Clarke, and A. N. Kingsnorth. 2010. "Cost-Effectiveness of Groin Hernia Surgery in the Western Region of Ghana." *Archives of Surgery* 145 (10): 954–61. doi:10.1001/archsurg.2010.208.

Simon, E. G., A. Chacko, A. K. Dutta, A. J. Joseph, and B. George. 2013. "Acute Nonvariceal Upper Gastrointestinal Bleeding: Experience of a Tertiary Care Center in Southern India." *Indian Journal of Gastroenterology* 32 (4): 236–41. doi:10.1007/s12664-013-0305-6.

Soper, D. E. 2010. "Pelvic Inflammatory Disease." *Obstetrics and Gynecology* 116 (2 Pt 1): 419–28. doi:10.1097/AOG.0b013e3181e92c54.

Stewart, B., P. Khanduri, C. McCord, M. Ohene-Yeboah, S. Uranues, and others. 2014. "Global Disease Burden of Conditions Requiring Emergency Surgery." *British Journal of Surgery* 101 (1): e9–22. doi:10.1002/bjs.9329.

Ugochukwu, A. I., O. C. Amu, M. A. Nzegwu, and U. C. Dilibe. 2013. "Acute Perforated Peptic Ulcer: On Clinical Experience in an Urban Tertiary Hospital in South East Nigeria." *International Journal of Surgery* 11 (3): 223–27. doi:10.1016/j.ijsu.2013.01.015.

Urassa, D. P., A. Carlstedt, L. Nystrom, S. N. Massawe, and G. Lindmark. 2005. "Are Process Indicators Adequate to Assess Essential Obstetric Care at District Level? A Case Study from Rufiji District, Tanzania." *African Journal of Reproductive Health* 9 (3): 100–11.

U.S. Department of Commerce, Bureau of the Census. 1935. *Mortality Statistics 1935: Thirty-Sixth Annual Report*. http://www.cdc.gov/nchs/data/vsushistorical/mortstatsh_1935.pdf/.

van Amelsfoort, J. J., P. A. van Leeuwen, P. Jiskoot, and Y. E. Ratsma. 2010. "Surgery in Malawi: The Training of Clinical Officers." *Tropical Doctor* 40 (2): 74–76. doi:10.1258/td.2009.090068.

van den Heuvel, B., B. J. Dwars, D. R. Klassen, and H. J. Bonjer. 2011. "Is Surgical Repair of an Asymptomatic Groin Hernia Appropriate? A Review." *Hernia* 15 (3): 251–59. doi:10.1007/s10029-011-0796-y.

Wani, I., M. Rather, G. Naikoo, A. Amin, S. Mushtaq, and others. 2010. "Intestinal Ascariasis in Children." *World Journal of Surgery* 34 (5): 963–68. doi:10.1007/s00268-010-0450-3.

WHO (World Health Organization). 2002. *World Health Report 2002: Reducing Risks, Promoting Healthy Life*. Geneva: WHO.

———. 2003. *Surgical Care at the District Hospital*. Geneva: WHO.

———. 2013a. "Global Health Estimates (GHE)." http://www.who.int/healthinfo/global_burden_disease/en/.

———. 2013b. "WHO Model List of Essential Medicines." http://www.who.int/medicines/publications/essentialmedicines/18th_EML_Final_web_8Jul13.pdf.