Chapter **67**

Surgery

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Countries with developing economies have not considered surgical care to be a public health priority, yet surgically treatable conditions—such as cataracts (Javitt 1993); obstructed labor (Neilson and others 2003); symptomatic hernias (Olumide, Adedeji, and Adesola 1976; Rahman and Mungadi 2000); osteomyelitis (Bickler and Rode 2002; Hilton 2003); otitis media (Smith and Hatcher 1992; Whitney and Pickering 2002); and a variety of inflammatory conditions—add a chronic burden of ill health to populations. These acute and chronic conditions take a serious human and economic toll and at times lead to acute, life-threatening complications.

Inadequacies in the initial care of injured patients (Hyder and Peden 2003; Jat and others 2004; Mock 2003; Mock and others 1995); of women with obstructed labor; and of children with treatable congenital anomalies, such as clubfoot (Ponseti 1999; Turco 1994) lead to preventable deaths or to chronic disabilities that make productive employment impossible and impose dependency on family members and society.

The role of surgery as a preventive strategy in public health needs to be studied and measured far more extensively than is currently the case. Another key reason for this study is that virtually all countries are developing their economies, and as a result, developing nations are increasingly facing a double burden—that is, the infectious diseases that have historically been so relevant and the conditions that emerge with economic development (for example, trauma from motorcycle, truck, and car accidents). The inclusion of a surgery chapter in this book recognizes that surgical services may have a cost-effective role in population-based health care. Recent studies (for instance, McCord and Chowdhury 2003) show that basic hospital service, which requires no sophisticated care, can be cost-effective, with a cost per disability-adjusted life year (DALY) that is much lower than might have been expected, and can be on a par with other well-accepted preventive procedures, such as immunization for measles and tetanus and home care for lower respiratory infections (Armandola 2003; Dayan and others 2004; Moalosi and others 2003; Ruff 1999).

We have identified four types of surgically significant interventions with a potential public health dimension: (a) the provision of competent, initial surgical care to injury victims, not only to reduce preventable deaths but also to decrease the number of survivable injuries that result in personal dysfunction and impose a significant burden on families and communities; (b) the handling of obstetrical complications (obstructed labor, hemorrhage); (c) the timely and competent surgical management of a variety of abdominal and extra-abdominal emergent and life-threatening conditions; and (d) the elective care of simple surgical conditions such as hernias, clubfoot, cataract, hydroceles, and otitis media.

NATURE, CAUSES, AND BURDEN OF SURGICAL CONDITIONS

Surgery is at the end of the spectrum of the classic curative medical model and, as such, has not been routinely considered as part of the traditional public health model. However, no matter how successful prevention strategies are, surgical conditions will always account for a significant portion of a population's disease burden, particularly in developing countries where conservative treatment is not readily available, where the incidence of trauma and obstetrical complications is high, and

where there is a huge backlog of untreated surgical diseases (Murray and Lopez 1996). Some surgical procedures can certainly be perceived as forms of secondary or tertiary prevention. Since the publication of the first edition of this book, which did not have a chapter on surgery, the health care community has recognized that the surgical management of some common conditions can indeed be a cost-effective intervention (Javitt 1993; McCord and Chowdhury 2003). The purpose of this chapter is to explore this hypothesis in more depth.

Methods for Determining Burden of Surgical Disease

We have arbitrarily decided to define a *surgical condition* as any condition that requires suture, incision, excision, manipulation, or other invasive procedure that usually, but not always, requires local, regional, or general anesthesia. We prefer this definition for two main reasons, to one that would define *surgery* as procedures performed by trained surgeons. First, surgery does not have to be performed by qualified surgeons. Indeed, in developing countries with few doctors, nondoctors can be trained to perform several types of operations satisfactorily. Second, we believe that the concept of surgery should include minor surgical procedures that nurses or general practitioners could perform along with nonoperative management of surgical diseases (for example, certain types of abdominal, thoracic, or head trauma and burns and infections). Any definition of surgery will have limitations, as has ours, and those limitations must be kept in mind when making interpretations, extrapolations, or estimates. Our broad definition is compatible with the concept of regionalized, coordinated, and interdependent services provided at the community clinic level and at the district and tertiary hospital levels. The most difficult task we then face is trying to determine the burden of surgical conditions as measured in DALYs. To our knowledge, this measurement has never been attempted. What we provide here is a starting point, with the understanding that the calculations will change as data are developed.

Our methodology was based on data from the *World Health Report 2002: Reducing Risks, Promoting Healthy Life* (WHO 2002) and the global burden of disease study (Murray and Lopez 1996). We began by listing all the conditions for which surgery might be indicated into three groups, with group I being communicable diseases, group II being noncommunicable diseases, and group III being injuries. We then undertook a comprehensive literature review for each condition to determine the proportion of the total burden of disease attributable to it and the proportion of the burden that could be prevented or treated by surgery. Essentially, we found no data of value except maybe for cataracts (group II-F), for which a single intervention (intraocular lens removal with or without implant) is or should ultimately be indicated for nearly 100 percent of patients (Dandona and others 1999; Javitt 1993). The *World Health Report 2002* attributes 8,269, of a total 1,467,257,000 DALYs, to cataracts (0.56 percent), and all those DALYs are considered potentially surgical. Maternal conditions (group I-C), perinatal conditions (group I-D), diabetes (group II-C), intentional injuries (group III-B), and unintentional injuries (group III-A), to name a few, are much broader categories of conditions for which the demarcation between the surgical and nonsurgical burden is not as clear as for cataracts.

Faced with a near total lack of pertinent data, we decided that the next best approach was to try to obtain consensus on a "best educated guess" for the surgical burden of each condition. We developed a survey instrument that listed all the possible surgical conditions (all potential surgical DALYs representing the maximum imaginable DALYs that could conceivably be surgical). We sent the questionnaire to 32 surgeons in various parts of the world, asking them what was, in their opinion, the proportion of each condition that would require surgery, which we have referred to as *estimated surgical DALYs* or the *conservative minimum*. For each of the 18 completed questionnaires, we discarded the two lowest and two highest values for each condition, leaving a sample of 14 surveys. The lowest value of this sample was consistently chosen so as to err systematically on the conservative side. Note that more than 90 percent of all retained values were within 10 percent of the chosen value. We then applied this value to the DALY numbers provided by the *World Health Report 2002* for each category of potentially surgical conditions.

Findings

Table 67.1 presents our estimates of the actual surgical burden for each category of potential surgical conditions for the world as a whole and by region. The table indicates that conditions requiring surgery account for a significant proportion of DALYs. Developing more refined, region-specific information to help policy makers will require more detailed data on the burden of surgical diseases (diseases requiring surgical treatment) and on the cost-effectiveness of surgical therapy. To this end, an extremely helpful step would be for international surgical associations to regularly monitor the disease burden attributable to surgical conditions throughout the world.

A few salient points about the burden of surgical diseases can be made from data provided in table 67.1. We estimate very conservatively that 11 percent of the world's DALYs are from conditions that are very likely to require surgery. Our estimated figures are as high as 15 percent for Europe and as low as 7 percent for Africa. Estimated surgical DALYs for the world are 27 per 1,000 population. The estimated figure is about twice as much for Africa (38 per 1,000) as for the Americas (21 per 1,000).

Table 67.2 summarizes the burden of common surgical conditions based on *World Health Report 2002* data. A more

Table 67.1 Estimated Surgical DALYs by Region

Region	Total DALYs (millions)	Estimated surgical DALYs (millions)	Estimated surgical DALYs as a percentage of total DALYs	Estimated surgical DALYs per 1,000 population
World	1,468	164	11	27
Africa	358	25	7	38
Americas	145	18	12	21
Eastern Mediterranean	137	15	11	30
Europe	151	22	15	25
Southeast Asia	419	48	12	31
Western Pacific	258	37	15	22

Source: WHO 2002 and authors' estimates.

Table 67.2 Burden of Common Surgical Conditions

Condition	Surgical DALYs		Estimated surgical DALYs as a percentage of total DALYs	Estimated surgical DALYs per 1,000 population
	Estimated (millions)[a]	Percentage		
Injuries	63	38	4.3	10
Malignancies	31	19	2.1	5
Congenital anomalies	14	9	1.0	2
Obstetrical complications	10	6	0.7	2
Cataracts and glaucoma	8	5	0.5	1
Perinatal conditions	7	4	0.5	1
Other	31	19	2.1	5

Source: WHO 2002 and authors' estimates.
a. *Estimated surgical DALYs* refers to our conservative estimate of DALYs averted by surgical treatment in the most likely diseases for the most likely indications.

detailed look at these data allows us to make the following observations:

- Injuries account for 63 million DALYs, or about 4 percent of all DALYs and 38 percent of the world's estimated surgical DALYs.
- Surgical infections, including infected wounds, superficial and deep abscesses, septic arthritis, and osteomyelitis, undoubtedly account for a significant portion of surgical DALYs, but the available data do not permit quantification.
- Surgical DALYs pertaining to acute abdominal conditions, including appendicitis, intestinal obstruction, gastrointestinal bleeding, hernias, and blunt or penetrating injuries also cannot be calculated because of the lack of data.
- Approximately one-third of maternal conditions, including hemorrhage, obstructed labor, and obstetrical fistulas, are surgical, and these represent 10 million DALYs, or 0.7 percent of all DALYs.
- *Congenital anomalies* refer to an ill-defined grouping of disparate pathologies that includes congenital malformations such as cleft lip and palate, hernias, anorectal malformations, and clubfoot. We estimate that some 50 percent of congenital anomalies are surgical, representing about 14 million DALYs, or 1 percent of all DALYs.
- Malignancies account for 31 million surgical DALYs, or slightly more than 2 percent of all DALYs.

Table 67.3 breaks down the burden of common surgical conditions by region, also showing rates per 1,000 population. The absolute burden of injuries is highest in Southeast Asia, followed by the Western Pacific and Africa. In terms of population rates, whereas injuries account for 10 DALYs per 1,000 population for the world, the estimated figure is almost twice as much for Africa (15 per 1,000) as for Europe (8 per 1,000). Similarly, rates of obstetrical complications are far higher in Africa than elsewhere, at 6 DALYs per 1,000 population. In

Table 67.3 Estimated Surgical DALYs by Condition and Region
(DALYs in millions followed by DALYs per 1,000 population in parentheses)

Condition	Africa	Americas	Eastern Mediterranean	Europe	Southeast Asia	Western Pacific
Injuries	10 (15)	7 (8)	6 (12)	7 (8)	20 (13)	13 (8)
Obstetrical complications	4 (6)	1 (1)	1 (2)	(<0.5)	3 (2)	1 (1)
Cataracts and glaucoma	1 (2)	(<0.5)	1 (2)	1 (1)	3 (2)	2 (1)
Malignancies	2 (3)	4 (5)	1 (2)	8 (9)	6 (4)	10 (6)
Perinatal conditions	2 (3)	1 (1)	1 (2)	(<0.5)	3 (2)	1 (1)
Congenital anomalies	2 (3)	2 (2)	2 (4)	1 (1)	4 (3)	3 (2)
Other	4 (6)	3 (4)	3 (6)	5 (6)	9 (6)	7 (4)

Source: WHO 2002 and authors' estimates.

contrast, Europe has the highest rate of surgical DALYS related to malignancies—9 per 1,000 population.

All these estimates are debatable. Work is needed to obtain more valid, accurate, and reliable data, but in the meantime, we believe that our results represent a conservative and acceptable baseline estimate of the burden of surgical conditions against which prospectively gathered data for given interventions can be compared in order to assess the extent to which they address the burden. In addition, the burden needs to be monitored over time. Evidence suggests that the burden of intentional and unintentional injuries is rising, particularly in Sub-Saharan Africa and the Middle East. Some of the important contributing risk factors include (a) aging populations; (b) increased access to and use of mechanized vehicles and tools without commensurate improvements in roads, traffic control systems, or capacity for trauma care; and (c) persistent armed conflicts (Kaya and others 1999; Krug, Sharma, and Lozano 2000; Meyer 1998; Mock and others 1995, 1999; Nantulya and Reich 2002; Peden and Hyder 2002).

INTERVENTIONS

Both population-based strategies and personal sevices provided in community clinic, district, and tertiary hospitals are considered in this section.

Population-Based Strategies

Population-based approaches to the prevention of unintentional and intentional injuries are discussed in the chapters on those topics. A population-based approach to injury should not, however, be limited to injury prevention. Patients may survive their primary injuries only to become chronically disabled and a burden to their families and to society (Krug, Sharma, and Lozano 2000; Mock and others 1999; Nantulya and Reich 2002; Peden and Hyder 2002). The incidence and severity of the complications of survivable injury may be significantly lessened by the provision of adequate surgical care during prehospital care and initial hospitalization. No published data from developing countries are available, however, either to prove this plausible contention or to quantify the benefits of adequate initial surgical treatment. A strategy to prevent chronic disability arising from survivable injury requires well-coordinated services for resuscitation, evacuation, and early and expert operative management of the initial injury.

Many other surgical conditions that can be treated electively, such as hernias, hydroceles, and otitis media, are treated when they present with complications requiring emergency surgery. Thus, a pertinent question is whether treating such conditions electively would be more cost-effective, but no reliable data are available to answer this question positively or negatively.

Population-based strategies could also be applied to prevent or treat some musculoskeletal conditions. For example, the incidence of clubfoot is estimated at 1 or 2 per 1,000 live births, but in developing countries these children are typically brought in for orthopedic care when it is too late for effective nonsurgical conservative management (Ponseti 1999; Turco 1994). Because we have no baseline data for the burden of clubfoot and other musculoskeletal conditions, we are unable to

quantify the DALYs that could be averted by comprehensive surgical care.

The following sections describe the organization of surgical services that we think would begin to provide coordinated surgical care in developing countries. The provision of surgical services in developing countries requires organizational structure and capacity at the level of community-based clinics, district hospitals, and tertiary care hospitals. Our concept of minimally adequate modules of surgical care is informed by our personal experiences, the experiences of others, and a recent World Health Organization report (WHO 2003). We recognize that to accommodate local needs and reality on the ground, any proposed plan to develop surgical services must be flexible. Table 67.4 presents our estimates of the needs for infrastructure, equipment and supplies, and workforce for the three levels of surgical care: community clinic, district hospital, and tertiary hospital.

Community Clinics

Table 67.4 shows resource and workforce requirements and types of surgical services a community clinic could provide for a population of around 20,000. We assume that surgical services in community clinics would be provided at no cost to patients. A cost-recovery system would be unlikely to succeed everywhere but, if implemented, should be equitable, with payments adjusted to patients' ability to pay. A mechanism for accountability and monitoring should be established to avoid the misuse of drugs and supplies. Simple patient records should be maintained, including outcomes of treatment and use of supplies. Even though the community clinic described here is what we think it should be as opposed to what we know it to be, our model may serve the needs of rural areas in developing countries and could provide a starting point for estimating costs.

District Hospitals

The next level of organization of surgical services is the district hospital, which in addition to providing primary care for the local population would also provide secondary-level surgical services and serve as a referral center for a number of community clinics in a defined region. In turn, the district hospital would ideally refer patients requiring complex surgical care to a tertiary-level hospital, but we recognize that such referral cannot always be achieved in practice because of transportation limitations, economic constraints, and prevalent social and cultural contexts. District hospitals vary in size from as small as 10 to 20 beds to as large as 200 to 300 beds and vary in their degree of sophistication in relation to diagnostic and therapeutic capabilities. For this discussion, we have arbitrarily chosen to focus on district hospitals with 100 beds or fewer.

Table 67.4 shows the infrastructure requirements for this type of hospital. Patients requiring more complex imaging studies and laboratory tests would be referred to the tertiary hospital.

To the extent possible, all equipment and supplies (table 67.4) should be standardized, and an efficient and reliable system for maintenance and replacement should be ensured. Operating room instruments and supplies should be available to enable the performance of laparotomy, thoracotomy, obstetrical and gynecological procedures, treatment of extremity fractures, skin grafting, and emergency burr hole of the skull. These instruments should be available at least in duplicate. Table 67.4 also shows workforce needs and the types of surgical procedures that may be performed in a district hospital.

The district hospital is assumed not only to serve as the referral hospital for community clinics, but also to coordinate the community clinics in its own region as a single operating unit, assuming responsibility for wireless communication, training the workforce, providing continuing medical education, and monitoring the quality and outcome of care. It would also provide primary care to its contiguous population.

Tertiary Hospitals

The tertiary hospital would function as the referral center for all complex surgical care in a region, country, or group of countries. Ideally, but depending on the country's resource constraints, it would provide the full range of care shown in table 67.4. The tertiary hospital would also provide primary surgical care for its local population and could take on the role of a teaching hospital for doctors, nurses, and other health care workers.

In the proposed organizational structure, the tertiary hospital is viewed as the top of a pyramid of surgical services, with several district hospitals referring patients requiring complex surgical care to the tertiary hospital. As such, it should also take the primary responsibility for coordinating and collaborating with all the district hospitals and community clinics in its area of responsibility to ensure that surgical care is available throughout the region and that well-functioning wireless communication and ambulance systems are available. If a regionalized system of separate ambulance services is not available, the tertiary hospital can provide the ambulance services required. Specialists in the tertiary hospital should provide telephone and electronic consultation for doctors and nurses in district hospitals. The tertiary hospital should also coordinate and monitor the quality of care in the region that serves as its referral base, undertake clinical outcome studies, and provide continuing medical education. In addition, it should be the main teaching hospital for medical students, nurses, and technicians, with the district hospitals and even the community clinics serving as clinical rotation sites for trainees. This organizational

Table 67.4 Resource Requirements for Surgical Services and Surgical Procedures by Level of Care

Category of requirement	Community clinic	100-bed district hospital	Tertiary hospital
Infrastructure	Weatherproof building (100 square meters) Storage space Clean water supply Power supply	Inpatient facility of 100 beds including several wards and an isolation ward Outpatient facility including an emergency room Operating rooms (at least two: one clean, one contaminated) Labor and delivery rooms Recovery room or intensive care unit Blood bank Pharmacy Clinical laboratory Radiology and ultrasonography suite	A major facility providing: • Full emergency services with advanced diagnostic services; • Inpatient wards for complex general medical and surgical care • Various types of specialty services • Several delivery rooms and operating rooms • One or more recovery rooms and intensive care units • Rehabilitation and occupational therapy facilities
Equipment and supplies	Furniture Refrigerator Blood pressure machine Minor surgical trays Sterile and burn dressings Autoclave Intravenous sets and solutions Bandages and splints Drugs: local anesthetics, nonsteroidal anti-inflammatory drugs, antibiotics, tetanus toxoid, silver nitrate ointment, oxytocin, magnesium sulfate Wireless communication equipment Materials for recordkeeping	Anesthetic machines and inhalation gases Monitors (electrocardiogram, blood pressure, pulse oximetry) Fully equipped operating room Fully equipped delivery room Fully equipped recovery room or intensive care unit Respirators and oxygen supply Blood products and intravenous fluids Basic microbiology equipment Pharmaceuticals (anesthetics, analgesics, antibiotics) Surgical materials (drapes, gowns, dressings, gloves) and other consumables (disposable equipment and devices)	All required equipment and supplies to undertake the range of routine and complex services provided
Human resources[a]	Nurse or nurse equivalent Skilled birth attendant Orderly	Nurses (20) Midwives (2–3) Anesthetists (2–3) Anesthesiologist (1)[b] Primary care physicians (4)[c] Obstetrician/gynecologist (1–2) General surgeons (2) Pharmacy assistants (2) Pharmacist (1)[b] Radiology technician (1) Radiologist (1) Physiotherapist (1)	Nurses (50) Midwives (5) Anesthetists (5) Anesthesiologists (3) Primary care physicians (10) Obstetricians/gynecologists (5) General surgeons (5) Orthopedic surgeon (1) Pharmacy assistants (2) Pharmacist (1) Radiology technicians (5) Radiologists (2) Physiotherapists (5) Neurosurgeon (1)[b] Cardiac surgeon[b] Reconstructive surgeon[b]

Table 67.4 Continued

Category of requirement	Community clinic	100-bed district hospital	Tertiary hospital
Services provided	Simple suturing and dressing of wounds Incision and drainage of abscesses Care of simple burns Control of hemorrhage Splinting Deliveries Vacuum extraction and manual vacuum aspiration	Emergency abdominal, thoracic, head injury Uncomplicated general surgical operations for hernias, anorectal conditions, and biliary tract disease Surgical infection treatment and control Obstetrical (including surgery for complications) Simple orthopedic care: extremity fractures, dislocations, and amputations Burn care Physiotherapy and occupational therapy Education and training	Full emergency service Management of all complex general surgery Full range of services in orthopedics, trauma, urology, otolaryngology, ophthalmology, and obstetrics and gynecology Basic (and, if resources permit, advanced) neurosurgery and cardiovascular surgery Intensive care services Major burn service Radiology services including CT and MRI imaging and angiography Full service clinical laboratory Physiotherapy Occupational therapy Training of doctors, nurses, and midwives

Source: Authors.

a. Because of the variability in size and the complexity of services provided by tertiary hospitals, it is difficult to describe a standard tertiary hospital; the human resource needs given in the table represent what we think are minimally adequate.

b. Desirable, but not absolutely necessary.

c. Can be a general internist, general practitioner, or general pediatrician.

structure is ideally suited for the tertiary hospital to serve as the backbone of community-based surgical education. The extent to which this ideal function of a tertiary hospital can be implemented will depend on the financial and other resources available to the country.

Coordinated Model System for Surgical Care

The proposed system for surgical services requires the coordination and integration of the following:

- wireless communication
- continuing education programs
- regionalized supply system for equipment, essential drugs, and surgical materials
- ambulance service
- uniform data collection system
- coordinated and ongoing monitoring of quality and outcomes of care.

A wireless system of communication could render costly wired systems unnecessary and could connect community clinics, district hospitals, and tertiary hospitals in a dependable way that facilitates consultation and referral. A Web-based system of communication could be particularly important for mentoring and for providing continuing medical education. The Web can also be used to enhance contributions by volunteer surgeons, anesthesiologists, surgical specialists, nurses, and technicians from around the world. Associations such as the International Surgical Association could develop a Web portal tied to national surgical associations to ensure greater success in this regard.

A regionalized system for the purchase and delivery of equipment and supplies is highly desirable. Such a system could ensure that all equipment and supplies were standardized and made available on demand in an efficient and predictable manner.

Ground ambulance services are essential for patient transfer. In some areas, collaboration with local taxi or bus services might offer the needed support. In some more economically advanced countries, tertiary hospitals might be able to provide ambulance services using fixed-wing aircraft or helicopters.

If the proposed model for a surgical system is to be developed, systems for ongoing data acquisition and for evaluation and monitoring should be built into the model. In this way, not only could information be captured, but also the quality and outcomes of care could be monitored on an ongoing basis.

COSTS AND COST-EFFECTIVENESS OF INTERVENTIONS

In today's resource-constrained world, policy makers increasingly need to be aware of the value of selective health care interventions. Cost-effectiveness analysis is one method that links inputs (costs) with the resulting health care gains measured along a common metric, usually using DALYs.

Even though an extensive body of literature examines the cost-effectiveness of a range of nonsurgical interventions in developing countries (Jha, Bangoura, and Ranson 1998), the literature examining surgical interventions in these countries is more sparse. Moreover, most of the available studies examine surgical interventions for specific conditions (Marseille 1996; Singh, Garner, and Floyd 2000). A common criticism of such studies is that they do not fully capture the choices policy makers face in real life. For example, policy makers must often choose between allocating resources for constructing several community clinics or a single district hospital, both of which provide a mix of surgical and nonsurgical services. Generally, the surgical ward in a district hospital will provide care for a wide range of conditions, such as trauma, childbirth, and abdominal conditions. We assume that for policy makers, knowing the cost-effectiveness of the surgical service, ward, or clinic (as an intervention) is more useful than information about the cost-effectiveness of each condition-specific surgical intervention. Unfortunately, no literature exists that examines the cost-effectiveness of a surgical service or ward. This section attempts to fill that void with respect to district hospitals and community clinics but not in relation to tertiary-level hospitals, which vary in size, available resources, and role from region to region, making it difficult to describe the cost-effectiveness of a prototypical tertiary hospital.

Method for Estimating Costs and DALYs

On the basis of the resource requirements listed in table 67.4, we developed cost estimates for each of the six regions defined by the World Bank. Table 67.5 details the assumptions and table 67.6 provides the regional costs. We defined the standard hospital in such a way as to facilitate comparisons across regions, conceptualizing it as a 100-bed hospital with a male ward and a female ward; two operating rooms; a recovery room, an intensive care unit, or both; an x-ray unit and an ultrasound machine; and a laboratory that can carry out basic blood chemistry tests, examine urine, and cross-match blood. This hospital also has an on-site laundry and kitchen and two vehicles to serve as ambulances. The staff consists of 6 doctors (4 primary care physicians, 1 obstetrician and gynecologist, and 1 general surgeon); 20 nurses; 6 midwives; 2 physiotherapists; and 6 orderlies. The costs of an anesthetist and x-ray technician have been included in the operating costs of the operating rooms and radiology area, respectively. The model assumes that the hospital averages 80 percent occupancy and that two-thirds of inpatients will be surgical cases.[1]

We defined a standard community clinic (see table 67.4) as a facility of 100 square meters serving a population of approximately 20,000, staffed by a nurse or nurse-substitute**,** a skilled birth attendant, and an orderly. Such a clinic treats approximately 4,000 surgical cases per year, with a *surgical case* being defined as treatment of bruises, simple cuts requiring suturing, foreign body removal, drainage of abscesses, basic burn treatment, normal deliveries, and simple trauma.

As far as possible, we used standardized regional cost estimates provided to the authors. When such information was unavailable, we used our consensus judgment. Given the wide variation in costs between and within regions, we conducted sensitivity analyses to capture the range of possible outcomes. When more than one source of cost estimates was available, the mean of the estimates for that region were used as the best estimate and a high-low range was noted. However, in many cases, only a single cost estimate could be obtained, in which case the data provide a point estimate,[2] and we vary the cost estimate by ±20 percent to obtain a high-low range.

Our calculation of the number of DALYs averted was based on the work of McCord and Chowdhury (2003), who calculate the DALYs averted by a 50-bed hospital in Bangladesh, as described in box 67.1. We adjusted this figure to reflect the bed size of our standard district hospital. In the absence of region-specific data, we applied this figure to all six regions after making suitable adjustments. For the community clinic, we estimated that such a clinic averts approximately 200 DALYs per year as a result of surgical treatment, primarily from the incision and drainage of abscesses and the preliminary treatment of burns. Because these DALY estimates are based on a single source, we vary the estimate by ±20 percent to obtain a high-low range and apply these estimates across the six regions.

Results

Figure 67.1 presents the results of the cost per DALY averted calculations for a district hospital and community clinic. The low estimate represents the scenario in which the costs are the lowest and the DALYs averted are the highest—that is, the best-case scenario. In a similar vein, the high estimate is the worst-case scenario: the costs are highest and the DALY averted is the lowest.

The best estimates for cost per surgical DALY averted at a community health center (panel a of figure 67.1) hover in a narrow range between US$212 and US$241. The cost per surgical DALY gained at a district hospital is cheapest for Sub-Saharan Africa at US$33 (range of US$19 to US$102) and most expensive for Latin America and the Caribbean at US$94 (range of US$47 to US$164).

Standard economic costs can differ from costs actually incurred in service delivery, both because in practice not all time may need to be paid for (for example, hospitals may be able to economize on staff because relatives help care for patients) and because low-cost solutions may be found (for example, use of paramedical staff members in place of professionals). Box 67.2 describes some of these strategies and compares the standard economic cost presented above with the much lower financial cost of a nongovernmental organization (NGO) hospital.

Table 67.5 Costing Assumptions for District Hospital and Community Clinic

Category	Assumptions and comments
100-bed district hospital	
Inpatient hospital bed days	The estimate includes "hotel" costs (capital, salaries, overhead, building, equipment, and food) for a hospital running at 80 percent occupancy. Assumption: two-thirds of all cases seen are surgical and costs are adjusted accordingly.
Operating rooms	The estimate includes all operating room–related costs (surgeon, nurses, equipment, and so on). Assumption: the operating room is running for 8 hours/day, 5 days/week, 52 weeks/year.
Laboratory	Assumption: 16 new admissions/day, all of whom will require a laboratory test once during their hospital stay. Yearly costs have been adjusted to reflect the percentage of surgical cases.
X-ray	Assumption: 16 new admissions/day, of whom half will undergo an x-ray examination once during their hospital stay. Yearly costs have been adjusted to reflect the percentage of surgical cases.
Pharmacy	Assumption: all admitted patients will use US$10 worth of drugs during their stay. Yearly costs have been adjusted to reflect the percentage of surgical cases.
Blood transfusion	Assumption: 400 units of blood transfused/year.
Ambulance	The estimate includes 2 ambulances; 15 percent markup for freight, insurance, and distribution; US$500/year running costs added; ambulance depreciated over 9 years.
Staff	
Nurses	Assumption: nurses devote two-thirds of their time to surgical patients and costs have been adjusted accordingly.
Midwives	Assumption: midwives devote 100 percent of their time to surgical patients.
Doctors	These are the four doctors whose costs have not been included in the operating room costs listed above. Because they provide ward coverage, two-thirds of their costs are attributed to surgical patients.
Physiotherapists	Assumption: physiotherapists devote two-thirds of their time to surgery patients.
Orderlies	Assumption: six orderlies, each devoting two-thirds of their time to surgical activities.
Community clinic	
Building costs	The estimate includes costs of lighting and power. Assumption: building size is 100 square meters, 20-year straight-line depreciation is used; 25 percent of costs are attributed to surgical patients.
Water supply	Assumption: US$20 for water supply, of which 25 percent attributed to surgery.
Supplies	The estimate includes surgical trays, sterile and burn dressings, intravenous sets and cannulas, bandages, splints, and plaster of Paris for 4,000 patients. Assumption: local costs of US$5/patient.
Drugs	The estimate includes local anesthetics, nonsteroidal anti-inflammatory drugs, tetanus toxoid, silver nitrate, and basic antibiotics. Assumption: 4,000 patients, US$5/patient.
Furniture	The estimate includes autoclave, surgical light, examination table, and beds. Assumption: total cost US$2,000, straight-line depreciated for 10 years.
Refrigerator	The estimate includes locally manufactured refrigerator, straight-line depreciated for 5 years; surgical cost attribution only.
Wireless telephone	Assumption: US$200 cost; 25 percent attributed to surgery.
Staff	
Nurses and nurse-substitutes	Assumption: nurses devote 25 percent of time to surgical duties and costs adjusted accordingly.
Skilled birth attendants	Assumption: attendants devote 25 percent of time to surgical duties and costs adjusted accordingly.
Orderlies	Assumption: orderlies devote 25 percent of time to surgical duties and costs adjusted accordingly.

Sources: Authors.
Note: The figures for the district hospital should be viewed with particular caution. First, we used a single source of data for our assumptions. Had we used other data sources, the results could conceivably be different. Second, as a prototype we used a Sub-Saharan Africa district hospital that provides basic, low-tech surgical services. The provision of more sophisticated care can be expected to drive up the costs of care significantly.

Discussion

The data in figure 67.1, when compared with similar data for other services presented in this book, indicate providing basic surgical services is relatively cost-effective. Figure 67.1 also indicates that, from a surgical perspective, the costs per DALY averted at a community clinic tend to be higher than those averted at a district hospital despite the lower costs of a community clinic. Although these observations may be taken as evidence that surgical services are best provided at the district hospital level, this goal may be impossible to put into practice.

Table 67.6 Annual Costs Attributable to Surgical Patients in a District Hospital and a Community Clinic, Best Estimates *(2001 U.S. dollars)*

Category	East Asia and the Pacific	Europe and Central Asia	Latin America and the Caribbean	Middle East and North Africa	South Asia	Sub-Saharan Africa
100-bed district hospital						
Inpatient hospital bed days	204,042	363,277	640,071	498,904	156,826	148,635
Operating rooms	778,752	1,130,688	1,163,136	896,064	526,656	419,328
Laboratory	34,304	44,403	45,251	37,619	27,058	23,974
X-ray	18,578	26,788	27,501	21,276	12,700	10,195
Pharmacy	38,544	38,544	38,544	38,544	38,544	38,544
Blood transfusion	7,572	8,548	8,632	7,892	6,872	6,572
Ambulance	7,389	7,389	7,389	7,389	7,389	7,389
Staff						
Nurses	24,652	29,808	58,591	95,227	21,973	30,390
Midwives	11,100	13,422	26,382	42,870	9,894	13,680
Doctors	11,856	14,340	28,187	45,807	10,571	14,618
Physiotherapists	3,522	4,258	8,370	13,604	3,139	4,341
Orderlies	5,714	6,914	13,587	22,081	5,097	7,045
Total	1,146,026	1,688,380	2,065,641	1,727,277	826,718	874,551
Community clinic						
Building costs	1,280	1,321	601	1,324	569	574
Water supply	5	5	5	5	5	5
Supplies	20,000	20,000	20,000	20,000	20,000	20,000
Drugs	20,000	20,000	20,000	20,000	20,000	20,000
Furniture	200	200	200	200	200	200
Refrigerator	10	10	10	10	10	10
Wireless telephone	50	50	50	50	50	50
Staff						
Nurses and nurse-substitutes	667	807	1,585	2,577	595	822
Skilled birth attendants	667	807	1,585	2,577	595	822
Orderlies	361	437	858	1,394	322	445
Total	43,240	43,635	44,895	48,136	42,345	42,928

Sources: All district hospital costs and community clinic building and staff costs: DCPP guidelines; other community clinic costs: authors' estimates.

The type of surgical care provided at the community clinic level, though not resulting in a very large DALY gain, is nevertheless important. It is inconceivable to think of a community clinic that does not have facilities for minor foreign body removal, simple suturing of cuts and wounds, or splinting of simple fractures. Furthermore, community clinics' referral and primary treatment functions, which are hard to evaluate separately from the delivery of final treatment, are critical for many conditions, notably trauma.

Costs per surgical DALY averted at the district hospital level seem to fall into three groups. Sub-Saharan Africa and South Asia are the cheapest, with the best estimates of cost per surgical DALY averted ranging between US$33 and $US38; Europe and Central Asia, Middle East and North Africa, and Latin America and the Caribbean seem to be the most expensive, with the cost per surgical DALY averted ranging between US$77 and US$94; and East Asia and the Pacific falls in the middle. This finding indicates that, from the perspective of providing surgical care, a district hospital is an exceptional "buy" in Sub-Saharan Africa and South Asia, both areas with high disease burdens. Coupled with evidence that district hospitals are comparatively underfunded compared with national (tertiary) hospitals (Fiedler, Wight, and Schmidt 1999), a prima facie case exists for increasing support for

Box 67.1

Estimation of the DALYs Averted by a Small Hospital in a Developing Country

The DALY estimates in this chapter are based on a report from a 40-bed nongovernmental hospital in rural Bangladesh in 1995 (McCord and Chowdhury 2003). Obviously this experience was localized from one hospital, in one country, at one time, but it is the only analysis available from such a hospital that estimates effectiveness using DALYs or any other measure of the effect of a hospital on the disease burden. The hope is that other similar studies done in a variety of hospital situations will permit generalizing with more confidence, but our personal experience leads us to believe that the disease pattern presented to small district hospitals in poor countries is remarkably constant, especially for surgical conditions.

McCord and Chowdhury (2003) present the methods for calculating DALYs in detail. They reviewed all discharges and deaths every week for three months, confirmed the discharge diagnosis by means of a chart review, and estimated the percentage chance that the hospital stay had prevented death or disability. The review covered all patients discharged, classifying them as medical, surgical, obstetrical and gynecological, or pediatric. Of the discharges, 62 percent were of surgical and obstetrical and gynecological patients. Of the DALYs, 21 percent of those averted were for surgical patients and 61 percent from obstetrical and gynecological patients. Eighty-nine percent of the estimated DALYs averted were generated by averting premature death, and only 11 percent by preventing serious disability. Of the 192 surgical operations, 118 were emergencies. Of 137 obstetrical patients, 81 had complicated deliveries, complications of abortion, or ectopic pregnancies.

Our estimates of the risk of death or serious disability were based on tables McCord and Chowdhury created and were necessarily arbitrary, but we believe they are extremely conservative. For example

- If the chance of death or disability was less than 5 percent, it was considered to be 0 percent. Because normal out-of-hospital deliveries had less than a 5 percent chance of death or disability, normal deliveries in the hospital made no contribution to the estimated DALYs averted.
- A cesarean section for obstructed labor was estimated at 10 percent averted risk for the infant and 0 percent for the mother.
- A cesarean for transverse lie was estimated at 90 percent averted risk for the infant and 90 percent for the mother.
- An appendectomy for nonruptured appendicitis was estimated at 10 percent averted risk, because many cases of appendicitis respond to antibiotics outside the hospital setting.
- An appendectomy for a ruptured appendix with generalized peritonitis was estimated at 90 percent averted risk.
- An elective herniorrhaphy for a small hernia was estimated at 0 percent averted risk.
- A herniorrhaphy for a large, disabling hernia was estimated at 80 percent averted risk.
- A herniorrhaphy for a strangulated hernia that did not reduce with conservative management was estimated at 80 percent averted risk.

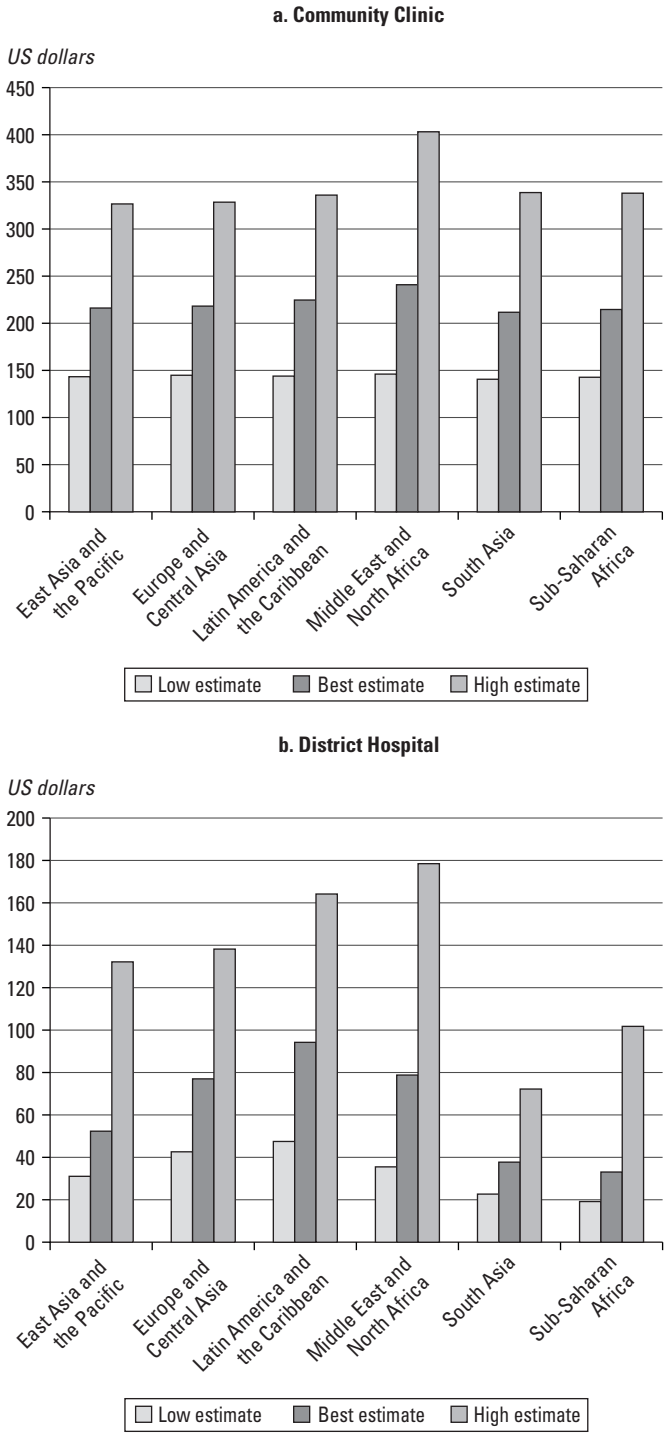
Source: Authors.

district hospitals in developing countries. However, those providing such support have to be cognizant of realities on the ground, especially political realities, because they have a significant effect on the direction of change (Blas and Limbambala 2001).

Data on the cost-effectiveness of surgical interventions for specific conditions in developing countries are scarce. One notable exception is for the surgical treatment of cataracts (removal of the opaque lens with or without the insertion of an intraocular implant). Blindness from cataracts is a significant public health problem in many developing countries, and as their populations age, estimates indicate that by 2020 more than 40 million people will be blind or almost blind because of cataracts (Brian and Taylor 2001). Box 67.3 describes a successful program in India.

RESEARCH AND DEVELOPMENT AGENDA

The literature on surgical care in developing countries is so meager that insufficient data are available to formulate an agenda for research and development. Hence, of necessity, the research that needs to be done is extremely basic, much of it



Source: Authors' calculations using costs in table 67.6 and methods for estimating DALYs averted described in box 67.1.

Figure 67.1 Cost per Surgical DALY Averted for a Community Clinic and a District Hospital

information gathering. The following are some of the areas that require investment in research and development:

- Estimates are needed of the burden of disease that requires surgical intervention along with a determination of region-specific DALYs that can be averted by means of surgical intervention. We have applied the DALYs averted from a single study in a developing country (McCord and Chowdhury 2003) to other regions, a procedure that negates regional differences in disease incidence, health care–seeking behavior, case mix, and clinical practice variations. In addition, the calculation of DALYs averted should ideally be adjusted for region-specific life expectancy and disability weights.
- Estimation of costs, both at a facility and regional level, is needed, including reducing variability in estimation methods (Adam and Koopmanschap 2003). In addition, multiple estimates of costs are needed. For example, Mulligan and others (2003) derive their operating room costs from a single study of ambulatory surgery in Colombia (Shephard and others 1993). Even though they made adjustments to reflect regional characteristics, further research is required to validate their results, especially as they apply to different settings in different countries.
- Better surgical data collection and analysis tools critical to needs assessment should be designed.
- Development of appropriate surgical care models for all levels of care based on local and regional characteristics and surgical needs would be useful.
- Cost-effectiveness and cost-benefit analyses of health systems implementation need to be determined, as do the policy implications of creating the surgical care model proposed in this chapter. The evaluation of surgery as a prevention strategy in public health should include cost-effectiveness analysis of adequate, prompt, initial surgical treatment of injury to prevent chronic disability from poorly diagnosed and treated survivable injuries and of elective treatment of hernia, hydrocele, otitis media, cataract, and clubfoot to prevent complications and disability.
- The surgical workforce in developing countries requires more in-depth study to look at the mixes of workers needed, the level of training required for the widely varying local situations of district hospitals, and the role for part-time surgical talent. The thesis is that volunteer doctors, nurses, and anesthesiologists who now contribute considerably to surgical care in developing countries in a relatively unstructured fashion could do so more effectively and in a manner that could help create sustainable local surgical workforces if a well-coordinated system with extensive information and communication support could be developed. This concept merits in-depth study. If a well-planned, Web-coordinated, global, highly integrated system could be developed, health care volunteers around the world could be organized strategically so as to deliver not only surgical care, but also training of local surgical workforces. The emphasis on training is crucial and would mitigate the complaints often heard that surgical volunteers too often contribute to the care of individual patients but fail to leave behind a

Box 67.2

Surgical Cost in a Bare-Bones Hospital

The estimated economic costs in this chapter assume staffing and service levels generally derived from World Health Organization recommendations for developing countries (Mulligan and others 2003), but in many places, surgical services are delivered in much simpler and less expensive facilities. Independent project hospitals (NGO hospitals) often operate on remarkably tight budgets. Private hospitals, often set up in private houses by individual surgeons, use locally trained staff with minimal "hotel" service. Extremely poor countries operate hospitals with a cost per patient per day of US$10 or less simply because they cannot afford more. Such hospitals achieve financial savings in several ways:

- Unpaid family members provide personal nursing care and food, eliminating the need for a kitchen and many trained nurses.
- Locally trained staff members substitute for professionally trained personnel.
- Many staff members have duplicate functions. In the operating room the same person may work as surgical assistant, scrub nurse, and orderly who cleans instruments or transports patients.
- Day staff members cover night calls for emergencies.
- Specialized services are provided by general physicians or technicians trained to do surgery or give anesthesia.
- Laboratory tests and x-rays are used sparingly. The only laboratory procedure for an obstetrical patient could be a hemoglobin determination.
- Only basic medicines are provided. More expensive or complicated supplies are purchased outside the hospital by the family.

For one independent, nongovernmental hospital in Bangladesh, we were able to obtain the actual financial cost of all aspects of hospital operations during a three-month period. These costs included salaries, supplies, hotel costs, and depreciated cost of equipment and buildings, as well as an overhead estimate to allocate a share of the total project cost for administration, electricity, transportation, and so on. Separating the surgical service costs for 3 months, extrapolated to 12 months and a 100-bed hospital, we come up with a much lower total cost than the low estimate in this chapter for the economic costs of a model district hospital, as shown in the table below. Part of the difference is caused by differing cost definitions (financial versus economic), but a good part is owing to the use of low-cost approaches to the delivery of surgical care.

Category	NGO hospital (2001 US$)	District Hospital in South Asia (2001 US$)
Inpatient bed days	110,936	156,826
Operating time	178,508	526,656
Laboratory	11,788	27,058
X-Ray	6,676	12,700
Pharmacy	n.a[a]	38,544
Blood transfusion	3,858	6,872
Ambulance	n.a.[a]	7,389
Staff	n.a.[b]	50,673
Total	311,766	826,718

Source: NGO hospital: McCord and Chowdhury 2003; district hospital: table 67.6.
n.a. = not available.
a. Included in overhead, which is added to each cost center.
b. Included in total cost of ward and operating room.

mechanism for sustaining surgical care when they have left. Those volunteers who come from the high-tech world of modern surgery should realize that the latest technology is often more of a burden and diversion than a help in poor countries. Convincing demonstrations of how much can be done without recourse to CT scans, ultrasound, and video-assisted surgery could be the most useful contribution a visitor could make.

Box 67.3

Success Story: Cataract Surgery in India

Prevention strategies aimed at known risk factors, such as tobacco use and exposure to the sun, are unlikely to have a significant effect on the need for surgical treatment of cataracts in the foreseeable future (Ellwein and Kupfer 1995). The benefits of cataract surgery have been well documented in many developing countries.

In 1993–94, with a World Bank credit of US$118 million, India expanded cataract surgery coverage to the disadvantaged with the goal of reducing the prevalence of blindness. District blindness control societies were set up and given the flexibility of financing different providers of cataract surgery services to low-income groups at the district level (Rose 1997). Mobile camps were a strategy adopted for providing cheap and efficient cataract surgery in rural districts. Because of these efforts, cataract surgery nationally increased from 1.2 million surgeries in 1991–92 to 2.7 million in 1996–97. Singh, Garner, and Floyd (2000) analyze the cost-effectiveness of publicly funded options for delivering cataract surgery in Mysore, India, by assessing outcomes in a systematic sample of patients operated on in 1996–97. Patient satisfaction was 51 percent among those operated on in government mobile camps, 82 percent among those treated at the medical college hospital, and 85 percent among those treated in nongovernmental hospitals. Cost-effectiveness was US$97 per patient treated for the mobile camps, US$176 for the state medical college hospital, and US$54 for nongovernmental hospitals. Javitt (1993) estimates the cost of cataract surgery in India at less than US$25 per DALY averted.

As the World Health Organization (Brian and Taylor 2001) has stressed, successful and sustainable surgical treatment of cataracts is linked to a spectrum of other equally important activities, including ongoing training of surgeons, nurses, and administrators; reliable and affordable supply chains; and equipment purchase and maintenance.

Source: Authors.

CONCLUSIONS

The inclusion of this chapter indicates the evolving appreciation that surgery has a role to play in public health strategies. Previous concerns that surgery is a curative intervention performed in expensive, high-tech hospitals precluded appreciation of the potential role of surgery in public health. Public health specialists now recognize not only that surgery has a preventive role, but also that surgical treatment provided in low-tech community hospitals is cost-effective. In addition, a significant number of surgical procedures, including cesarean sections and other abdominal operations, can be successfully performed by surgical technicians (Jamisse and others 2004; Pereira and others 1996).

Surgery has an important role as a public health strategy in at least four areas:

- in the prevention of death and chronic disability in injured patients by the provision of timely, expert, and complete initial surgical treatment
- in the timely surgical intervention in obstructed labor, in pre- and postpartum hemorrhage, and in other obstetrical complications
- in the provision of competent surgery to treat a wide range of emergency abdominal and nonabdominal conditions
- in the surgical care of several elective conditions that have a significant effect on the quality of life, such as cataract, otitis media, clubfoot, hernias, and hydroceles.

Few published data are available to enable reliable estimates of either the burden of surgical diseases or the cost-effectiveness of surgical treatments in a region-specific manner to help policy makers and voluntary groups. This area merits a great deal of attention in relation to research and development. Nevertheless, the clear conclusion is that surgery must be considered a public health priority.

NOTES

1. This structure is based on the authors' personal experiences of practicing in developing countries. We have defined *surgical cases* to include deliveries and cesarean sections.

2. For example, operating room costs are based on the results of a single study by Shepard and others (1993).

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