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Systematic Review of Met and Unmet Need of Surgical Disease in Rural Sub-Saharan Africa

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Abstract
Background Little is known about the burden of surgical disease in rural sub-Saharan Africa, where district and rural hospitals are the main providers of care. The present study sought to analyze what is known about the met and unmet need of surgical disease.
Methods The PubMed and EMBASE databases were searched for studies of surveys in rural areas, information on surgical admissions, and operations performed within rural and district hospitals. Data were extrapolated to calculate the amount of surgical disease per 100,000 population and the number of operations performed per 100,000 population. These extrapolations were used to estimate the total, the met, and the unmet need of surgical disease.
Results The estimated overall incidence of nonfatal injury is at least 1,690/100,000 population per year. Morbidity as a result of injury is up to 190/100,000 population per year, and the annual mortality from injury is 53–92/100,000. District hospitals perform 6 fracture reductions (95% CI: 0.1–12)/100,000 population per year and 14 laparotomies (95% CI: 7–21)/100,000 per year. The incidence of peritonitis and bowel obstruction is unknown, although it may be as high as 1,364/100,000 population for the acute abdomen. The annual total need for inguinal hernia repair is estimated to be a minimum of 205/100,000 population. The average district hospital performs 30 hernia repairs (95% CI: 18–41)/100,000 population per year, leaving an unmet need of 175/100,000 population annually.
Conclusions District hospitals are not meeting the surgical needs of the populations they serve. Urgent intervention is required to build up their capacity, to train healthcare personnel in safe surgery and anesthesia, and to overcome obstacles to timely emergency care.

Introduction

Little is known about the extent of morbidity and mortality from surgical disease within rural sub-Saharan Africa. A number of estimates of surgical conditions have been made. Nordberg [1] estimated the incidence of significant injuries within rural East Africa to be 40,000/100,000 per year, with an estimated mortality of 100/100,000 per year; the incidence of cancer (all sites) to be 120/100,000 per year, with mortality of 60/100,000 per year; and the incidence of delivery complications to be 1,000/100,000 per year, with mortality of 30/100,000 per year. He also estimated the minimum need for cesarean sections, routine inguinal hernia repairs, and strangulated hernia repair to be 225, 175, and 30 per 100,000 population per year, respectively [2].

The second edition of Disease Control Priorities for Developing Countries (DCP2) estimated the number of DALYs (disability adjusted life years) as a result of surgical conditions around the world by using a "best educated guess" survey of 18 surgeons worldwide [3]. Their estimates are almost certainly very conservative, but the results include an estimated 38 DALYs per 1,000 population in Africa, including injuries, malignancies, congenital

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anomalies, obstetric complications, cataracts and glaucoma, and perinatal conditions. However, this does not include surgical infections, wounds, abscesses, septic arthritis and osteomyelitis, or DALYs due to acute abdominal conditions, such as hernia, appendicitis, gastrointestinal bleeding, and the like, because of the paucity of data.

A systematic review of uterine rupture worldwide estimated the prevalence for less and least developed countries to be between 0.1% and 1%. Some 75% of uterine ruptures in studies from Africa and Bangladesh were associated with an unscarred uterus. Maternal mortality ranged between 1% and 13% [4].

Taira et al. [5] conducted a systematic review of English language publications to assess the burden of surgical disease in developing countries across the world. Single-institution studies and studies based on a geographic region smaller than a city were excluded. They summarized what little is known globally about the burden of surgical disease in developing countries and concluded that there is very limited access and availability of surgical care across the developing world.

The aim of the present study was to estimate the met and unmet need of surgical disease in rural sub-Saharan Africa through a review of the available literature. First, the total need was determined by reviewing all community-based studies of surgical disease in rural areas to gain an idea of the incidence and prevalence of surgical disease. Second, the met need was determined by reviewing all published admission and operating data from district hospitals to gain an idea of how much surgical illness was being met at local healthcare facilities. The unmet need was then estimated by measuring the gap between these two data sets. For the purposes of this study, a surgical condition is defined as "any condition that requires suture, incision, excision, manipulation, or other invasive procedure that usually, but not always, requires local, regional, or general anesthaesia" [3]. "District hospital" included rural mission hospitals as providers of surgical care to rural populations.

Methods

The PubMed and EMBASE databases were searched using combinations of the MeSH headings "Africa," "General Surgery," "Epidemiology," "Surgical Procedures, Operative," "Health Care Surveys," "Developing Countries," "Wounds and Injuries," "Urology," "Orthopedics," and "Hospitals, District," as well as the subject headings "district hospital," "Africa," and "surgery." Studies were included if they were community-based surveys in rural areas, or if they gave information about the surgical admissions or the common operations performed within rural and district hospitals. Studies were excluded if they were not English, or were audits of fewer than 100 people. Dental and ophthalmic conditions were excluded. Although we initially looked at data from central and regional referral hospitals, there was no information in the articles as to how far people had traveled or which patients had been referred from district hospitals and rural areas, and these articles were therefore excluded. The PubMed "Related Articles" algorithm was used, and references were searched to find other relevant papers. The results are illustrated in Fig. 1.

Of 230 articles initially identified, 126 were excluded as they did not meet initial inclusion criteria. The remaining 104 abstracts and full text articles were further examined, and 65 of those were excluded, 35 of which reported data from tertiary and city referral hospitals. Thus, 39 studies were included in the final analysis.

Articles were divided according to whether they were epidemiological studies of surgical morbidity, epidemiological studies of surgical mortality (the total need), district hospital data on surgical admissions, or district hospital data on surgical operations (the met need). District and rural hospital data were included as an integral part of the study because such information gives an indication of the degree to which district hospitals serving rural populations are managing to respond to the surgical disease burden.

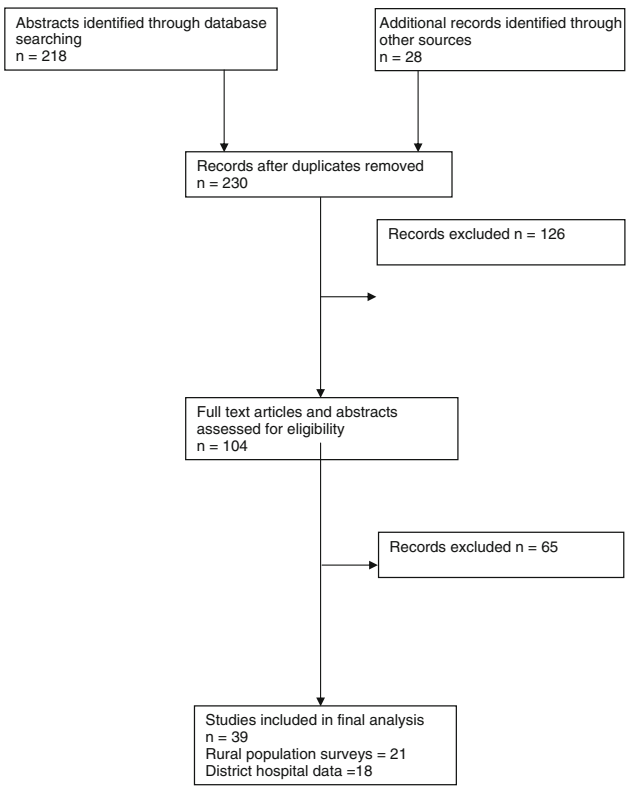

Fig. 1 Study outline

Data within the papers were adjusted in order to produce comparisons between studies, wherever possible determining the met and total need per 100,000 population.

Overall, the heterogeneity in study design, terminology, methodology, data presentation, and data analysis made comparisons between studies difficult. In addition, countries within sub-Saharan Africa differ widely in their development, and so, for example, countries with good transport systems tended to report much higher rates of transport-related injury. Although we sought to distinguish between studies performed in urban and rural areas, often the distinction was far from clear. However, as far as possible, data were extracted from studies and then converted to a form that made comparison between studies possible.

Results

Total need: morbidity

Table 1 shows the articles that met the inclusion criteria for community-based surveys of surgical morbidity in predominantly rural areas. Despite significant differences in terminology and methodology, the overall rate of morbidity as a result of injury was high. The incidence of nonfatal injury in rural areas differed depending on the methodology. In Kenya, Nordberg et al. [12] estimated nonfatal injuries to be 3,000 per 1,000 population—three injuries per person per year. This is explained by the two week recall period and the fact that more than half of these were minor injuries—cuts and piercings—which would not normally require any medical attention. In Uganda, Kobusingye et al. [6] used more stringent criteria and a six-month recall period and estimated an incidence of 1,690 injuries/100,000 per year, a figure similar to the incidence of injuries in rural Pakistan, where it was calculated to be 1,531/100,000 [23]. Transport-related injury contributes a significant burden to the overall injury rate, and although not usually the most common form of injury in rural areas, where it does occur, causes significant morbidity and disability. Other common causes of injury in rural areas are cuts and stabs, falls, and burns. The prevalence of musculoskeletal impairment as a result of trauma was estimated to be 1.9%, and disability as a result of injury was estimated to affect between 0.7 and 1.8% of the population.

According to Peltzer, children have a particularly high rate of serious injury, with an overall incidence of 38.6%–71.5% of school children per year across six East African countries, although serious injury in this study was defined as ‘‘when it makes you miss at least one full day of usual activities (such as school, sports, or a job) or requires treatment by a doctor or nurse” [13]. In another study of schoolchildren, fracture prevalence (i.e., the percentage of children who had sustained a fracture at any time in the past) among Zambian secondary school children was 19% for males and 11% for females [14]. Time since the injury was highly variable: 25% of those who had limb fractures had “significant impairment,” defined as “functional, anatomical, or other related problems,” as a result. However, this does not give us data on children who do not go to school, and who may be at greater risk of injury.

For burns, the number of people who gave a history of burn was 5% of household members, with 6.1% of children having scars from previous burns. Of note, 17.4% of these children had burn-related physical impairment.

A single study on obstetric fistula in Ethiopia gave an overall prevalence of obstetric fistula of 2.2/1,000 women aged 15–49 years, a figure that fits well with estimates from the Demographic Health Surveillance surveys, indicating a lifetime prevalence of fistula symptoms between 2.6 and 4.7 in sub-Saharan Africa [24].

Therefore, the estimated overall incidence of nonfatal injury in rural sub-Saharan Africa is at least 1,690 per 100,000 population per year, with morbidity as a result of injury having a prevalence of up to 190 per 100,000 population.

Total need: mortality

Table 2 shows the articles that met the inclusion criteria for community-based surveys of mortality from surgical causes. All articles looked at injuries, four of which related to violence and war and one focused on road traffic injuries. Mortality from injuries, even in the absence of war is high, ranging between 53 and 92 per 100,000/year. A Nigerian study looked at the mortality specifically from road traffic injuries and calculated this to be approximately 1.6/1,000 per year, although 60.5% of those interviewed lived in urban areas.

A number of countries in sub-Saharan Africa suffer from civil war or tribal infighting. Studies that looked at the effect of war on injury rates reported much higher mortality, with the excess mortality rate reported as 6.85/1,000 per year in northern Uganda, 0.4–0.7/100,000 per month at two different time points in the Democratic Republic of Congo, and up to 93% of all deaths in West Darfur related to war.

Overall, household surveys of surgical disease in rural sub-Saharan Africa showed very high levels of morbidity and mortality due to trauma, and to a lesser extent burns, with little data on surgical burden outside of these disease areas.

District hospital admissions

Table 3 shows the data from district hospital admissions. Eight articles related to surgical admissions to district

Table 1 Population-based studies—morbidity

References	Condition	Number in study	Method	Incidence/prevalence
Kobusingye et al. [6]	Injuries	Rural: 1,673 households (7,427 persons)	Household survey in rural and urban settings	Incidence of nonfatal (disabled and recovered) injuries was 16.9/1,000 population per year; disability as a result of injury 0.7% rural (2.8% urban)
Labinjo et al. [7]	Road traffic injuries	3,082 people	Population survey of road traffic injuries; head of household interviewed—1 year recall period. 60.5% lived in urban areas	Overall RTI rate was 41/1,000 population per year (95% CI: 34–49) Motorcycle injuries 54%
Lett et al. [8]	Injuries	8,595	Population survey of injury in three districts affected by war, and compared with one district not affected by war	14% of study population were injured annually; annual rate of disabled and recovered was 36.8/1,000
Mock et al. [9]	Injuries	21,105 (urban and rural)	Household interviews—1 month recall period for minor injuries; 1 year recall for major injuries	Overall incidence of minor injuries was 383.2/1,000 person years (178.2/1,000 person years urban); incidence of major injuries was 20.49/1,000 person years (19.4/1,000 person years urban)
Mock et al. [10]	Transport-related injuries	21,105 (urban and rural)	Household interviews (urban and rural areas) on any injury occurring during the preceding year resulting in 1 or more days of lost activity, or any disability resulting from an injury occurring more than a year previously	Annual incidence of transport-related injuries was almost identical in the two settings: 9.41/1,000 rural
Moshiro et al. [11]	Injuries	15,223	Household interviews: all injuries reported that resulted in one or more days of restricted activity—1 year recall	4.3% had an injury during the previous year (2.5% urban)
Nordberg et al. [12]	Injuries	1,980	Interview of household heads and focus group discussions in four rural villages and five urban clusters; 2 week recall period	300,000 injuries per 100,000 people per year total
Peltzer [13]	Injury (WHO Global School based Health Survey)	20,765	Cluster sampling followed by surveys administered in classrooms of everyone who had suffered a serious injury in the preceding 12 months	Mean incidence over previous 12 months of serious injury was 68.2%, ranging from 38.6% in Swaziland to 71.5% in Zambia
Krabbe et al. [14]	Fractures	355	Retrospective survey of secondary school students who had ever sustained a limb fracture	Fracture prevalence of 19% of males and 11% of females; 25% had led to significant impairment
Atijosan et al. [15]	Musculoskeletal impairment	6757	Household interview followed by clinical examination	Overall 5.2% (95% CI 4.5–5.9) of musculoskeletal impairment, of which 37.8% were traumatic, 13.3% were neurological, and 4.4% were infective; mild (42.1%), moderate (42.1%), and severe (15.8%)
Disler et al. Part I [16]	Locomotor disability	9,112	Household survey	Prevalence of locomotor disability, 11.2/1,000 population
Disler et al. Part II [17]	Locomotor disability	2,072	Household survey	Prevalence of locomotor disability, 18.3/1,000 population
Disler et al. Part III [18]	Locomotor disability	2,391	Household survey	Prevalence of locomotor disability, 13/1,000. Main cause was illness. 77.4% of injured, 60 years of age or older
Belcher et al. [19]	Morbidity	14,729	Household survey. Concentrated on households of pre-school children and mothers—2 week recall period	20.8% reported some form of illness, injury, or disability over previous 2 weeks; 32% lasted more than 2 weeks; 12.9% were musculoskeletal

Table 1 continued

References	Condition	Number in study	Method	Incidence/prevalence
Courtright et al. [20]	Burns	163 households	Household survey of adult members	21% of households had history of burn; 5% of household members had history of burn
Forjuoh et al. [21]	Burns	15,742	Community-based survey to identify children who had scars as evidence of previous burns	6.1% (95% CI: 4.9–7.3) of children had scars from previous burns. 17.4% of those children with burns scars had burn-related "physical impairment," mostly keloid (Forjuoh et al. [32])
Muleta et al. [22]	Obstetric fistulae	19,153 households with 48,176 females	In-depth interviews with fistula patients	2.2/1,000 women aged 15–49

hospitals. Three related to burns, two related to injuries, one to pediatric admissions with data on trauma and burns, and one to general surgical admissions. An attempt was made to calculate the number of surgical admissions per 100,000 population in the catchment area, using approximate population areas published within each article, or census data if available.

Again, the data are heterogeneous, coming from a variety of hospitals serving rural populations. For burns, two articles from hospitals in South Africa gave an admission incidence of between 3.4 and 44 per 100,000 population per year. Data extrapolated from an article from Zambia estimated the burns admissions to be 29.3/100,000 children per year.

Data from district hospitals in Ethiopia showed that of 33.95 surgical admissions per 100,000 population per year, 64.8% were emergencies, of which trauma accounted for 36.7% and intestinal obstruction 10.3%. Mortality was high for these surgical conditions, 47% mortality for trauma and 38.3% mortality for obstruction. However, a rural mission hospital in Kenya reviewed 202 admissions with injury and had an overall mortality rate of 3.5%. Of note, the main injury in these trauma patients were limb fractures. Trauma admissions were also common among pediatric admissions in Zambia, accounting for an (extrapolated) 82.6/100,000 children per year.

Met need: district hospital operations

Finally, to look at the extent to which district hospitals are meeting the surgical need, we reviewed all articles that gave details of surgical operations performed (Tables 4 and 5). Table 4 outlines the common operations performed in the district hospitals in each article, with the data extrapolated where possible to give the proportion of total operations for each procedure. Table 5 uses data from population estimates, either from within the published article or from other sources where possible, to give an estimate of the number of operations performed per 100,000 catchment area population. Where elective and emergency procedures were distinguished—e.g., elective versus emergency hernia repairs—these were combined in order to compare with articles that did not make that distinction.

On reviewing all the data, it became apparent that there is a very wide discrepancy between hospitals, even within the same district of the same country, as to the operations that they perform. Cesarean section is the most commonly performed operation and seems to be most widely available. Despite the very high incidence of trauma, burns, and intestinal obstruction picked up from other parts of this review, the number of fracture reductions, laparotomies, and skin grafts is small. Herniorraphy also features

Table 2 Population-based studies: mortality

References	Condition	Number of people in study	Methods	Mortality rate
Kobusingye et al. [6]	Injuries	Rural: 1,673 households and 7,427 persons Urban: 2,322 households with 10,982 persons	Household survey in rural and urban settings; 5 year recall period for fatal injuries	Rural injuries 92/100,000 persons per year (urban: 217/100,000 per year
Labinjo et al. [7]	Road traffic injuries	3,082 people from 553 households across 7 of the 39 states	Population survey of road traffic injuries Head of household interviewed; 1 year recall period; 60.5% lived in urban areas	Overall mortality from RTIs was 1.6/1000 (95% 95% CI: 0.5–3.8)
Mock et al. [9]	Injuries	21,105 (urban and rural)	Household interviews; 1 year recall period	Injury-related mortality was 83/100,000 population urban; 53/100,000 population rural
Moshiro et al. [25]	Injuries	Total numbers of deaths were 5,049 (Dar es Salaam), 9,339 (Hai), and 11,155 (Morogoro)	Prospective study over 6 years of deaths in one urban and two rural districts using annual/biannual census	Deaths due to injuries accounted for 5% of all deaths urban; 8% and 5% in the two rural areas
Lett et al. [8]	Injuries and war	8,595	Population survey of injury in three districts affected by war, and compared with one district not affected by war	Death rate from injury was 7.8/1,000 population per year (95% CI 7.0–8.5 (annual excess injury mortality: 6.85/1,000
Coghlan et al. [26]	Violence and war	19,500 households	National survey using interviews of heads of households; 15 month recall period	Violent death rate per 100,000/month was 0.2 (West)—4.5 (East). Violence accounted for 0.7 deaths/100,000 population per month for all eastern health zones
Coghlan et al. [27]	Violence and war	14,000 households	National survey using interviews of households; 15 month recall period	Deaths from violence accounted for 0.4/100,000 per month
Depoortere et al. [28]	Violence and war	215,400	Retrospective cluster surveys	Mortality in three different sites was 5.9, 9.5, and 7.3/10,000 day; violence accounted for 68%–93% of these deaths

RTIs road traffic injuries

Table 3 District hospital data: admissions

References	Methodology	Results	Catchment population	Admissions/100,000/year
Admassu [29]	Retrospective study of all surgical admissions	679 admissions. 64.8% were emergencies Adult admissions: trauma 36.7% with 47% mortality; intestinal obstruction 10.3% all surgical admissions with 38.3% mortality Pediatrics: abscess 12.2%; appendicitis 9.8%, with surgical cases accounting for 28% of all pediatric admissions	~2 million	Surgical admissions: 33.95/100,000/yr
Allorto et al. [30]	A prospective database was maintained of all burn patients admitted	450 patients admitted, 203 of them children (0–12 years); etiology of burn, flame, 70%; hot water, 25%; miscellaneous, 5%; 40 deaths (9%). Etiology burn in the deaths: fire ($n = 30$); lightning ($n = 4$); hot water ($n = 6$)	~3 million	Burns admissions: 8.2/100,000/year total; 6.7/100,000/year children
Justin-Temu et al. [31]	Prospective questionnaire of parents/carers of children under 5 years old who had burns; quantitative study	204 patients, 54.9% aged 1–2 years: 78.4% scalds, 21.6% flame burns	Not stated	
Chopra et al. [32]	Retrospective analysis of case notes of consecutive pediatric burn cases	149 children: 88 (59%) admitted; 19 (22%) developed wound infections, 5 (6%) developed contractures; 1 death	~200,000	Burns admissions: 44/100,000/year
Odero et al. [33]	Retrospective descriptive study of all patients with injuries	315 injured patients, most common injuries: 36.6% struck by object (i.e, cuts and bruises); 34.4% assault; 11.6% falls; 4.7% RTAs	~40,000	Number presenting: 1,350/100,000 per year RTAs: 63.45/100,000/year
Otieno et al. [34]	Prospective audit of consecutive trauma patients admitted	202 patients admitted, injury mechanisms: 52% RTAs; 22% falls; 13% assault; 6% burns; overall mortality rate, 3.5%	Not stated	
Gernaat et al. [35]	Combined retrospective and prospective study of children admitted	349 (5.4%) admissions were due to trauma; 124 (1.9%) due to burns	Estimated district population 105,681	Trauma admissions: 82.6/100,000 children/year Burns admissions: 29.3/100,000 children/year

RTAs road traffic accidents

Table 4 District hospital operations: breakdown of selected operations

References	Study design	Main general surgical operations performed	Main orthopedic operations	Main obstetric/gynecological operations
Galukande et al. [36]	Retrospective study of 8 district hospitals in 3 countries	% of all procedures performed: Wound-related procedures: 10%–50% Herniorrhaphy: 5%–13% Laparotomy: 1%–17% Appendectomy: 0%–5% Skin graft: 0%–3%	% of all procedures performed: Open fracture reduction: 0%–15% Limb amputation 0%–5%	% of all procedures performed: Cesarean section: 10%–50% Uterine evacuation and D&C: 0%–13% Hysterectomy 0%–7% Emergency obstetric hysterectomy 0%–2% Repair of ruptured uterus 0%–4%
Lavy et al. [37]	Retrospective study of 21 district hospitals and 4 central hospitals	Combined % of all procedures performed: Suture/debridement of wound: 14% Hernia repair: 3% Laparotomy: 2% Skin graft: 0.1% Other and unspecified: 19%	Combined % of all procedures performed: Manipulation of fracture: 5% Osteomyelitis surgery: 2% Arthrotomy: 2% Debridement of open fracture: 1%	Combined % of all procedures performed: D&C: 26% Cesarean section: 24%
Nabembezi and Nordberg [38]	Two year retrospective review of a single district hospital	% of all major procedures performed (1996/1997): Herniorrhaphy: 18%/31% Laparotomy: 12%/12.6% Appendectomy: 0.9%/1% % of all minor procedures performed (1996/1997): Incision and drainage: 51%/48% Wound suturing: 18.3%/21%	% of all major procedures performed (19196/1997): Amputations: 1.2%/0.3% % of all minor procedures performed(1996/1997): POP application/removal: 7.6%/4.7%	% of all major procedures performed (1996/1997): Cesarean section: 44%/37% Hysterectomy: 5.7%/5.2% % of all minor procedures performed (1996/1997): Evacuation of uterus: 8.1%/7.4%
Nordberg et al. [39]	One year review of all operations performed in 4 hospitals	% of total operations: Hernia repair: 2.5% Laparotomy: 7.2% Prostatectomy: 1.1% Appendectomy: 0.9%	% of total operations: Limb amputation: 0.7% Open reduction of fracture: 1.7%	% of total operations: Cesarean section: 48.8% Hysterectomy: 2% Tubal ligation: 14.6%
Nordberg [40]	Hospital annual reports from 4 East African hospitals in 1983	Rates per 100,000: Inguinal hernia: 8–107 Other hernia: 1–20 Hydrocele: 2–56 Reconstructive, including skin grafting: 8–17 Obstructed hernia: 1–5 Appendectomy: 2–5	Rates per 100,000: Amputation: 2–10 Open reduction including fixation of fracture: 3–20	Rates per 100,000: Cesarean section: 13–51 Ectopic pregnancy/adnexectomy: 4–14 Uterus rupture/hysterectomy: 1–21

Table 4 continued

References	Study design	Main general surgical operations performed	Main orthopedic operations	Main obstetric/gynecological operations
Rahlenbeck and Hakizimana [41]	Review of all registered deliveries over a 4 year period at a district hospital	Not applicable	Not applicable	3,408 women delivered 3,497 neonates. 26% had cesarean section (1.1% of population)
Sani et al. [42]	Review of all procedures over a 1 year period performed at 3 district hospitals	% of elective surgery: Inguinal hernia: 64.5% Umbilical hernia: 16.3% Hydrocele: 13.3% % of emergency surgery: Laparotomy: 11.1% Strangulated hernia: 4.4%	Not stated. But 66.1% of transfers to the regional referral hospital were fractures	% of emergency surgery: Cesarean section: 70% Hysterectomy for uterine rupture 7.8%
Potter [43]	Retrospective study of all operations performed in a rural mission hospital over a 10 year period	% of all general surgical procedures ($n = 4{,}485$): Hernia repair (non-strangulated): 41.8% Hernia (strangulated): 6.7% Laparotomy: 9.2% Skin graft: 4.9%	Not broken down. Total number = 1,311; 60% of the work is reduction and immobilization of fractures; 10% are patients with osteomyelitis	% of all obstetrics/gynecology procedures ($n = 3{,}152$): D&C: 33.2% Cesarean section: 10.2% Vesicovaginal fistula repair 3.4% Hysterectomy 2.9%
Chopra et al. [32]	Retrospective study of all children < 15 admitted to a rural district hospital	149 children presented; 88 admitted; 20 children required 32 procedures: 19 skin grafts 10 wound debridements 3 contracture releases	Not applicable	Not applicable
Willmore and Hill [44]	Retrospective review of cases of acute appendicitis seen at a rural mission hospital over a 5 year period	112 cases of acute appendicitis. Operative findings were 14% normal appendix, 42% simple appendicitis, 22% perforated appendix, 21% abscess; wound infection rate 22%	Not applicable	Not applicable
Otienoet al. [34]	Prospective audit of 202 trauma patients admitted to rural mission hospital	Main interventions (*n*): Suturing and debridement (46) Chest drain (17) Blood transfusion (15) Split-thickness skin grafting (11) Laparotomy (10) Burr holes/craniotomy (5) Thoracotomy (4)	Main interventions (*n*): Fracture open reduction and internal fixation (51) Fracture/dislocation reduction with POP (46) Skeletal/skin traction (35) Fracture reduction external fixation (11)	Not applicable

Table 4 continued

References	Study design	Main general surgical operations performed	Main orthopedic operations	Main obstetric/gynecological operations
Loutfi [45]	Retrospective 6 month audit of operating log books and outpatient records of 2 central hospitals, 3 regional hospitals, 2 rural hospitals, and 5 health centers	Of 695 procedures at the two rural hospitals: Wound repair: 13% Incision and drainage of abscess: 3.9% Chest drain: 1.2% Skin grafting: 0.1% Groin hernia: 1.9% Circumcision: 8.8% Appendectomy: 2% Emergency laparotomy: 9.4%	Of 695 procedures at the two rural hospitals: Amputation: 1.9% Closed reduction of fracture: 5.6% Internal fixation: 1.3%	Of 695 procedures at the two rural hospitals: Cesarean section: 4.3% D&C: 12.9%
Watters and Bayley [46]	One year retrospective audit of all operations performed at 5 district and church hospitals	% of all general surgical operations: Abscess drainage: 2.3%–74% Hernia 0%–19.2% Circumcision: 0.7%–38.7% Amputation: 0%5.4% Laparotomy: 0%11.9%	Not recorded	Not recorded

D&C dilatation & curettage

Table 5 District hospital operations: data per 100,000 population

References	Hospital	Total major operations	C-section	Herniorraphy	Laparotomy	Tubal ligation	Hysterectomy	Number of manipulations	Total minor operations	I&D	Wound suturing	D&C
Galukande et al. [36]	Bagamoyo	380	114	48	11	11	11	6	52	1,675 in total	Combined with I&D	56
	Kasulu	180	87	9	10	4	1	0	146			31
	Chokwe	250	133	13	15	5	7	2	23			0
	Catandica	240	80	26	13	5	0	0	13			1
	Mityana	450	176	70	5	17	8	52	101			53
	Kiryandongo	50	10	5	3	9	1	0	106			0
	Buluba	60	23	8	3	0	1	0	4			0
	Iganga	300	147	37	56	0	22	0 (open fracture reduction)	38			0
Lavy et al. [37]	All 21 district hospitals[a]	226.2 (all operations)	54.3	6.8	5.6	Not stated	Not stated	12.3	Not stated	Not stated	25.7	58.6
Nabembezi and Hakizimana [38]	Kagadi district hospital, Kibaale district	166 and 155/100,000 (major) for 1996 and 1997, respectively	73.5 and 57 in 1996 and 1997	30 and 48 in 1996 and 1997, respectively	19.5 and 19.5	14.5 and 6	9.5 and 8	7 in 1996 and 4.5 in 1997 (POP application/ removal)	93 in 1996, 95 in 1997	94 and 92[b]	Not stated	Not stated
Nordberg [47]	Major operations in 10 hospitals in East Africa: Kenya, Tanzania, southern Sudan, Ethiopia (5 government, 5 non-government)	Not stated	13	17	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated
			24	2								
			10	9								
			25	8								
			4	13								
			20	39								
			43	28								
			44	77								
			36	53								
			62	114								
Nordberg et al. [39]	Meru	383	223	7	16	74	0.7	1.3	2,066 (total for all hospitals, and other clinics in the district)	207	330	64
	Nkubu	262	133	7.2	23	2.8	12	9.7				
	Chogoria	259	70	9.7	5	56	5	4.4				
	Maua	136	82	0	13	33	1.2	2.4				
	Tigania	119	88	2.6	14	0	2.6	0.6 (Open reduction)				

Table 5 continued

References	Hospital	Total major operations	C-section	Herniorraphy	Laparotomy	Tubal ligation	Hysterectomy	Number of manipulations	Total minor operations	I&D	Wound suturing	D&C
Nordberg [40]	Nkinga,Tanzania	532	51	132	Not stated	Not listed	21	Not stated	417	75	33	27
	Kabanga,Tanzania	68	13	21			3		–	–	–	–
	Ndala, Tanzania	203	24	40			9		775	370	76	11
	Kilgoris, Kenya	230	24	19			4		2853	198	149	161
Rahlenbeck and Hakizimana [41]	Byumba, Rwanda	Not stated	48[c]	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated
Sani et al. [42]	Dosso, Niger 1 RRH + 3DH	49.2	13	20.5	1.72	Not stated	1.45 – all emergency for uterine rupture	Not stated. But 76 with fractures were transferred to the RRH	Not stated	Not stated	Not stated	Not stated.
Mean (95% CI)		224 (167–280)	63 (44–81)	30 (18–41)	14 (7–20)	17 (6–27)	6 (3–9)	6 (0.1–12)	357 (68–646)	181	123	41

[a] Using total rural population estimated at 11,076,354 based on 2008 Malawi Census and 84.7% living in rural areas

[b] Part of total minor operations; also included evacuation of uterus

[c] Population catchment: 470,000, 1997–2000 (4 years 26% of all deliveries and 6.4% of all admissions is 190/100,000 over 4 years or 48/100,000 per year)

I&D, *RRH* regional referral hospital, *DH* district hospital

prominently as the second most commonly performed operation, with an overall mean incidence of 30/100,000 population, reflecting a mixture of both elective and emergency herniorraphy. A much larger number of smaller procedures are performed, including incision and drainage of abscesses and wound suturing and management. Where recorded, these procedures are very commonly performed, but they are frequently not recorded in operating room logbooks as some may be done in the outpatient setting under a local rather than a general anesthetic.

The unmet need: injury and fractures

We calculated that if at least 1,690/100,000 have a nonfatal injury and 53–92/100,000 die as a result of injury, then even assuming that the majority of nonfatally injured people do not require hospital treatment and that some fatally injured people would never make it to a hospital, even with good emergency transport systems, we would still expect at least 200/100,000 population needing some form of urgent medical care. If, as the article by Otieno et al. suggests, at least half of those admitted as a result of trauma need some form of fracture reduction, and district hospitals perform a mean number of 6 fracture reductions per 100,000 population, then the unmet need for fracture management would be in the region of 194 per 100,000 population per year [34]. However, most fractures are managed on an outpatient basis and may not be recorded in hospital records.

The unmet need: laparotomies

Although there have not been any surveys of the incidence of acute abdominal conditions in sub-Saharan Africa, a survey from rural Pakistan estimated the incidence to be 1,364/100,000 [22]. It is possible that a similar number may apply in rural Africa, and if so, and the number of laparotomies performed in district hospitals is only 14/100,000, the unmet need for acute abdominal conditions would be 1,350/100,000 population per year. If we also take into account figures from central hospitals, for example using the Malawi data [37], we still end up with 4,062 laparotomies performed in total for a population size of 11,076,354 [48]—i.e., only 36/100,000 population per year for the entire (rural and urban) population.

The unmet need: hernias

No household survey has been performed to look at the prevalence of untreated inguinal hernia. However, if we take Nordberg's [2] original estimates, then the total need for non-strangulated and strangulated hernia would be 205/100,000 per year. This may be a very conservative estimate, however, as unpublished data reported by Shillcutt et al., from northern Ghana, estimate the need to be at least 1,400/100,000 population [49]. If an average district hospital performs 30 hernia operations (elective and emergency) per 100,000 population per year, then the unmet need is at least 175/100,000 per year for inguinal hernia repairs.

Interestingly, by comparison, if we use Nordberg's estimated need for cesarean section to be at least 225/100,000 population, we have calculated that the average district hospital performs a mean number of 224 per 100,000 population. However, if district hospitals were meeting the need for cesarean section, that would not explain why sub-Saharan Africa is estimated to have the highest maternal mortality rate, accounting for almost three fifths of all maternal deaths worldwide [50]. It may be that those district hospitals that perform operations and have published data are largely meeting the need within their local areas, or it may be that Nordberg's original estimate was inaccurate.

Discussion

Overall, our review shows a very high burden of trauma and injuries in rural areas, high numbers of patients with injuries and bowel obstruction being admitted to hospital, but few fracture fixations or laparotomies being performed in the operating rooms at the district hospitals. It is possible that some of these patients are referred onto secondary care, but it is not known how many people either do not seek formal health care at all or are unable to access it because of structural, financial, or cultural barriers.

Two studies compared numbers of operations performed in district hospitals with numbers from the local regional referral hospitals [37, 45]. As might be expected, the variety of different operations performed locally, their complexity, and the numbers performed were generally very much higher than at the district hospitals. For example, Loutfi and Pickering [45] found that for the 70 laparotomies performed at rural hospitals, 150 were performed at the regional hospital and 185 at the central hospital. For fracture fixation, 9 were performed at the rural hospitals, 128 at the regional facilities, and 291 at the central hospital. Lavy et al. [37] found that the district hospitals in Malawi performed 618 laparotomies, compared with 3,444 in the four central hospitals in that country. For internal fixation of fractures, 8 were performed at the district level and 532 were performed at central hospitals.

There are a number of drawbacks with this study. First, there is a fundamental lack of data surrounding how many people have significant morbidity or mortality as a result of surgical illness within rural areas. Although there are a

handful of studies on injury, trauma, and violence, this only forms a part of a wide spectrum of surgical disease. Second, in the various articles reviewed, a wide variety of terms are used to describe surgical disease, injury, trauma, impairment, disability, etc., which makes comparing studies on apparently similar subjects confusing. Third, a number of operations and procedures are done outside of the district hospitals. For example, satellite health centers can perform some smaller procedures [45]. In addition, some patients may go directly to a regional referral hospital, or be referred from a district hospital to a secondary or tertiary center. Referrals are not routinely recorded, so it is difficult to know how many patients are being referred. Fourth, in order to identify the burden of disease, we looked at both government district hospitals and rural mission hospitals. Nordberg [2] demonstrated that hospitals supported by nongovernmental organizations (NGOs) do many more operations than the district hospitals, and it is therefore questionable whether the care they provide is really typical of rural care.

We assumed that hospitals that have admission and operating figures published are typical of district hospitals, although this may well not be the case. We also assumed that district hospitals in different countries are similar, and this may not be the case either. Finally, we have assumed that the distribution of surgical conditions is equal across Africa. However, there are isolated studies suggesting that this is not the case. Eckhart [51] recognized a significant difference in the number of strangulated hernias diagnosed at hospitals in Ethiopia, Uganda, and Kenya. He proposed that the difference in numbers was due to anatomical variation. Shija [52] noted that the distribution of hydrocele, inguinal hernia, and volvulus was unevenly distributed across Tanzania, corresponding to a similar distribution of mean annual rainfall.

However, our study does show that there is a significant discrepancy between the surgical care needed and that provided. This is likely to be a result of the combination of an inability of district hospitals to provide the care required, and difficulties with patients accessing that care.

A number of articles have described the lack of capacity in many district hospitals to meet local surgical and anesthesia needs. This is due to lack of resources, lack of manpower [53], and the need for training. The World Health Organisation's Situational Analysis Tool has been used in a number of studies that show the lack of capability of district hospitals to provide basic procedures because they lack infrastructure, supplies, and personnel [54–59]. A study using pulse oximeter availability as a measure of operating room resources showed that between 58.4% and 78.4% of operating rooms in West Africa, East Africa, and central sub-Saharan Africa do not have pulse oximetry [60].

It is therefore essential that district hospitals are better equipped and funded, and that staff are adequately trained in elective and emergency surgical care. However, this is likely to be difficult to achieve when surgery accounts for an estimated 11% of the global burden of disease and resources are limited [3]. The Bellagio Essential Surgery Group published four recommendations for increasing access to surgical care in sub-Saharan Africa [61]. First, they recommended that services be strengthened at the district hospital level; second, that systems be improved for the delivery of trauma care; third, that there is a need to expand the supply and quality of health workers with surgical skills; and finally, that there was a need to build evidence to inform interventions to improve access. If all of these were made priorities, then we would expect to see a massive increase in the number of operations being performed at district hospitals.

Another initiative in this regard is the World Health Organisation Global Initiative for Emergency and Essential Surgical Care [62]. This is an international collaboration that aims to strengthen capacity to deliver essential and emergency surgical care at the first referral level, improve the quality of care, and strengthen training programs in surgery. District hospitals with integrated functioning surgical units warrant investment as they are cost-effective [63, 64] and have the ability to raise the overall quality of health care, as well as having a specific effect on Millennium Development Goals 4 (reduction of child mortality), 5 (reduction of maternal mortality), 6 (combat of HIV/AIDS, malaria, and other diseases), and 1 (halving the number of people living in poverty) [65, 66].

It would be expected that training programs and improved facilities at the district hospital level would increase the number of operations performed and decrease referrals to higher levels of care, and this appears to be the case. Sani et al. [42] showed that providing 12 months of training to general practitioners in district hospitals in Niger significantly reduced the number of transfers to the local regional hospital from 635 to 115, although of note, 66.1% of the 115 patients transferred had fractures, 10.4% had uterine rupture, and 10.4% had abdominal or thoracic trauma.

We have previously reviewed the barriers that patients encounter when attempting to access surgical care in rural sub-Saharan Africa and identified significant cultural, structural, and financial barriers. It is essential that, along with patient and community education, transportation needs to be available and road quality must be improved. Up-front costs for all emergency care must be eradicated and the prohibitive costs to the patient of elective care must be overcome [67].

Finally, at present there is no measure of the quality of surgery being performed at district hospitals, nor of the

effect of surgical procedures on patient quality of life in such a setting, and further research is needed in these areas.

Conclusions

District hospitals in rural sub-Saharan Africa are not currently meeting the surgical needs of the populations they serve, with resulting significant morbidity and mortality. The reasons for this are multifaceted. Urgent intervention is required to build up the capabilities and capacity of district hospitals and train healthcare personnel in safe surgery and anesthesia. Along with this, upfront costs of emergency care must be eradicated and emergency transport infrastructure needs to be provided to ensure that those suffering from trauma, injury, obstructed labor, or other emergencies are able to access care rapidly.

References

1. Nordberg E (2000) Injuries as a public health problem in sub-Saharan Africa: epidemiology and prospects for control. East Afr Med J 77(12 Suppl):S1–43
2. Nordberg EM (1984) Incidence and estimated need of caesarean section, inguinal hernia repair and operation for strangulated hernia in rural Africa. Br Med J 289(6437):92
3. Debas H, Gosselin R, McCord C et al (2006) Surgery. In: Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M et al (eds) Disease control priorities in developing countries, 2nd edn. Oxford University Press, New York, pp 1245–1259
4. Hofmeyr GJ, Say L, Gulemzoglu AM (2005) WHO systematic review of maternal mortality and morbidity: the prevalence of uterine rupture. BJOG 112:1221–1228
5. Taira BR, McQueen KAK, Burkle FM (2009) Burden of surgical disease: does the literature reflect the scope of the international crisis? World J Surg 33:893–898
6. Kobusingye O, Guwatudde D, Lett R (2001) Injury patterns in rural and urban Uganda. Inj Prev 7:46–50
7. Labinjo M, Juillard C, Kobusingye OC et al (2009) The burden of road traffic injuries in Nigeria: results of a population-based survey. Inj Prev 15:157–162
8. Lett RR, Kobusingye OC, Ekwaru P (2006) Burden of injury during the complex political emergency in northern Uganda. Can J Surg 49:51–57
9. Mock CN, Abantanga F, Cummings P et al (1999) Incidence and outcome of injury in Ghana: a community-based survey. Bull World Health Org 77:955–964
10. Mock CN, Forjuoh SN, Rivara FP (1999) Epidemiology of transport-related injuries in Ghana. Accid Anal Prev 31:359–370
11. Moshiro C, Heuch I, Astrøm AN et al (2005) Injury morbidity in an urban and a rural area in Tanzania: an epidemiological survey. BMC Public Health 285:11
12. Nordberg E, Kimani V, Diwan V (2000) Household survey of injuries in a Kenyan district. East Afr Med J 77:240–244
13. Peltzer K (2008) Injury and social determinants among in-school adolescents in six African countries. Inj Prev 14:381–388
14. Krabbe CA, Rutten JP, Phiri Y et al (2003) Prevalence and outcome of paediatric and adolescent limb fractures in rural Zambia. S Afr J Surg 41:89–91
15. Atijosan O, Rischewski D, Simms V et al (2008) A national survey of musculoskeletal impairment in Rwanda: prevalence, causes and service implications. PLoS One 3(7):e2851
16. Disler PB, Jacks E, Sayed AR et al (1986) The prevalence of locomotor disability and handicap in the Cape Peninsula. Part 1. The coloured population of Bishop Lavis. S Afr Med J 69:349–352
17. Disler PB, Jacks E, Sayed AR et al (1986) The prevalence of locomotor disability and handicap in the Cape Peninsula. Part II. The black population of Nyanga. S Afr Med J 69:353–355
18. Disler PB, Jacks E, Sayed AR et al (1986) The prevalence of locomotor disability and handicap in the Cape Peninsula. Part III. The white population of Fish Hoek. S Afr Med J 69:355–357
19. Belcher DW, Wurapa FK, Neumann AK et al (1976) A household morbidity survey in rural Africa. Int J Epidemiol 5:113–120
20. Courtright P, Haile D, Kohls E (1993) The epidemiology of burns in rural Ethiopia. J Epidemiol Community Health 47:19–22
21. Forjuoh SN, Keyl PM, Diener-West M et al (1995) Prevalence and age-specific incidence of burns in Ghanaian children. J Trop Pediatr 41:273–277
22. Muleta M, Fantahun M, Tafesse B et al (2007) Obstetric fistula in rural Ethiopia. East Afr Med J 84:525–533
23. Ahmed M, Ali Shah M, Luby S (1999) Survey of surgical emergencies in a rural population in the Northern Areas of Pakistan. Trop Med Int Health 4:846–857
24. Johnson K, Peterman A (2008) Incontinence data from the demographic and health surveys: comparative analysis of a proxy measurement of vaginal fistula and recommendations for future population-based data collection. DHS Analytic Studies No. 17
25. Moshiro C, Mswia R, Alberti KG, the AMMP Project Team et al (2001) The importance of injury as a cause of death in sub-Saharan Africa: results of a community-based study in Tanzania. Public Health 115:96–102
26. Coghlan B, Brennan RJ, Ngoy P et al (2006) Mortality in the Democratic Republic of Congo: a nationwide survey. Lancet 367:44–451
27. Coghlan B, Ngoy P, Mulumba F et al (2009) Update on mortality in the Democratic Republic of Congo: results from a third nationwide survey. Disaster Med Public Health Prep 3:88–96
28. Depoortere E, Checchi F, Broillet F et al (2004) Violence and mortality in West Darfur, Sudan (2003–4): epidemiological evidence from four surveys. Lancet 364:1315–1320
29. Admassu A (2000) Analysis of surgical admissions to Debre Markos Hospital. Trop Doct 30:185–186
30. Allorto NL, Oosthuizen GV, Clarke DL et al (2009) The spectrum and outcome of burns at a regional hospital in South Africa. Burns 35:1004–1008
31. Justin-Temu M, Rimoy G, Premji Z et al (2008) Causes, magnitude and management of burns in under-fives in district hospitals in Dar es Salaam, Tanzania. East Afr J Public Health 5:38–42
32. Chopra M, Kettle H, Wilkinson D et al (1997) Paediatric burns in a rural South African district hospital. S Afr Med J 87:600–603
33. Odero W, Polsky S, Urbane D et al (2007) Characteristics of injuries presenting to a rural health centre in western Kenya. East Afr Med J 84:367–373
34. Otieno T, Woodfield JC, Bird P et al (2004) Trauma in rural Kenya. Injury 35:1228–1233
35. Gernaat HB, Dechering WH, Voorhoeve HW (1998) Clinical epidemiology of paediatric disease at Nchelenge, north-east Zambia. Ann Trop Paediatr 18:129–138
36. Galukande M, von Schreeb J, Wladis A et al (2010) Essential surgery at the district hospital: a retrospective descriptive analysis in three African countries. PLoS Med 7(3):e1000243
37. Lavy C, Tindall A, Steinlechner C et al (2007) Surgery in Malawi—a national survey of activity in rural and urban hospitals. Ann R Coll Surg Engl 89:722–724

38. Nabembezi JS, Nordberg E (2001) Surgical output in Kibaale district, Uganda. East Afr Med J 78:379–381
39. Nordberg E, Mwobobia I, Muniu E (2002) Major and minor surgery output at district level in Kenya: review and issues in need of further research. Afr J Health Sci 9:17–25
40. Nordberg E (1990) Surgical operations in eastern Africa: a review with conclusions regarding the need for further research. East Afr Med J 67(3 Suppl):1–28
41. Rahlenbeck S, Hakizimana C (2002) Deliveries at a district hospital in Rwanda, 1997–2000. Int J Gynaecol Obstet 76:325–328
42. Sani R, Nameoua B, Yahaya A (2009) The impact of launching surgery at the district level in Niger. World J Surg 33:2063–2068. doi:10.1007/s00268-009-0160-x
43. Potter AR (1982) Surgery in an African bush hospital. Med J Aust 13:469–471
44. Willmore WS, Hill AG (2001) Acute appendicitis in a Kenyan rural hospital. East Afr Med J 78:355–357
45. Loutfi A, Pickering JL (1993) The spectrum of surgery in Ethiopia. Can J Surg 36:91–95
46. Watters DA, Bayley AC (1987) Training doctors and surgeons to meet the surgical needs of Africa. Br Med J (Clin Res Ed) 295(6601):761–763
47. Nordberg EM (1984) Incidence and estimated need of caesarean section, inguinal hernia repair and operation for strangulated hernia in rural Africa. Br Med J 289:92
48. 2008 Population and Housing Census. National Statistics Office of Malawi. http://www.nso.malawi.net/index.php?option=com_content&view=article&id=106&Itemid=6. Accessed 13 Apr 2011
49. Shillcutt SD, Clarke MG, Kingsnorth AN (2010) Cost-effectiveness of groin hernia surgery in the Western Region of Ghana. Arch Surg 145:954–961
50. Trends in maternal mortality: 1990 to 2008. Estimates developed by WHO, UNICEF, UNFPA and The World Bank. http://www.who.int/reproductivehealth/publications/monitoring/9789241500265/en/index.html. Accessed 13 Apr 2011
51. Eckhart P (1964) The incidence of strangulated hernia in Busoga, Uganda. East Afr Med J 41:59–62
52. Shija JK (1975) The geographical distribution of inguinal hernia, hydrocoele and intestinal volvulus in Tanzania. E Afr J Med Res 2:265–271
53. Ozgediz D, Kijjambu S, Galukande M et al (2008) Africa's neglected surgical workforce crisis. Lancet 371(9613):627–628
54. Taira BR, Cherian MN, Yakandawala H et al (2010) Survey of emergency and surgical capacity in the conflict-affected regions of Sri Lanka. World J Surg 34:428–432. doi:10.1007/s00268-009-0254-5
55. Choo S, Perry H, Hesse AA et al (2010) Assessment of capacity for surgery, obstetrics and anaesthesia in 17 Ghanaian hospitals using a WHO assessment tool. Trop Med Int Health 15:1109–1115
56. Iddriss A, Shivute N, Bickler S et al (2011) Emergency, anaesthetic and essential surgical capacity in the Gambia. Bull World Health Organ 89:565–572
57. Contini S, Taqdeer A, Cherian M et al (2010) Emergency and essential surgical services in Afghanistan: still a missing challenge. World J Surg 34:473–479. doi:10.1007/s00268-010-0406-7
58. Kingham TP, Kamara TB, Cherian MN et al (2009) Quantifying surgical capacity in Sierra Leone: a guide for improving surgical care. Arch Surg 144:122–127
59. Kushner AL, Cherian MN, Noel L et al (2010) Addressing the Millennium Development Goals from a surgical perspective: essential surgery and anesthesia in 8 low- and middle-income countries. Arch Surg 145:154–159
60. Funk LM, Weiser TG, Berry WR et al (2010) Global operating theatre distribution and pulse oximetry supply: an estimation from reported data. Lancet 376(9746):1055–1061
61. Lubuga S, Macfarlane SB, von Schreeb J et al (2009) Increasing access to surgical services in sub-Saharan Africa: priorities for national and international agencies recommended by the Bellagio Essential Surgery Group. PLoS Med 6(2):1–5
62. http://www.who.int/surgery/globalinitiative/en. Accessed 7 Mar 2011
63. McCord C, Chowdhury Q (2003) A cost effective small hospital in Bangladesh: what it can mean for emergency obstetric care. Int J Gynecol Obstet 81:83–92
64. Gosselin RA, Thind A, Bellardinelli A (2006) Cost/DALY averted in a small hospital in Sierra Leone: what is the relative contribution of different services? World J Surg 30:505–511
65. PLoS Medicine Editors (2008) A crucial role for surgery in achieving the UN millennium development goals. PLoS Med 5:e182
66. Grimes C, Lavy C (2010) A plea for investment in district hospitals. Lancet 376:2073
67. Grimes CE, Bowman KG, Dodgion CM et al (2011) Systematic review of barriers to surgical care in low-income and middle-income countries. World J Surg 35:941. doi:10.1007/s00268-011-1010-1