Paediatric surgery and anaesthesia in south-western Uganda: a cross-sectional survey

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Objective To study paediatric surgery rates in south-western Uganda, compare them to rates in England, and determine if existing surgical facilities and workforce meet World Health Organization (WHO) standards.

Methods To obtain information on surgical facilities and workforce, we conducted a cross-sectional survey of all hospitals performing major surgery in 14 districts of south-western Uganda in 2007–2008. Using theatre logbook data, we determined the surgical rates, types of surgery performed and in-theatre surgical outcomes.

Findings Of 72 hospitals surveyed, 29 were performing major surgery. None met WHO standards for essential surgery. There were 0.7 accredited surgeons per 100 000 population and no paediatric surgeons. Most anaesthetists were not physicians (accredited anaesthetist per 100 000 population: 1.1).

The annual surgical rate for children aged ≤ 14 years was 180 operations per 100 000 population; most were emergency procedures. The annual surgical rate for patients of all ages was 652 operations per 100 000 population, with a median of 422 per operating theatre (range: 60–3497) and of 226 per surgeon (range: 60–1748). Mission or nongovernmental organization (NGO) hospitals, which had 44% of the hospital beds in the region, performed 3039 (55%) of the paediatric operations. Externally funded surgeons performed 80% of the 140 cleft lip and palate operations. Four in-theatre deaths occurred in children ≤ 14 years old (in-theatre mortality: 7.7 deaths per 10 000 operations).

Conclusion Access to all surgery, including paediatric surgery, is poor in south-western Uganda and investment in basic health-care facilities and surgical workforce and training is urgently needed. Mission and NGO hospitals make a valuable contribution to elective surgery, and externally funded surgeons make an important contribution to specialist surgery. In-theatre mortality was lower than reported for similar settings.

Une traduction en français de ce résumé figure à la fin de l'article. *Al final del artículo se facilita una traducción al español.* الترجمة العربية لهذه الخلاصة في نهاية النص الكامل لهذه المقالة.

Introduction

Despite increasing awareness of the unmet burden of surgical conditions, little information is available on surgery and anaesthesia in children.[1] It has been estimated that 85% of children in low-income countries are likely to require treatment for a surgical condition by the age of 15 years.[2] Many surgical conditions of childhood are amenable to simple surgical intervention, but if left untreated, complications, lifelong disability or death can ensue.[3]

The World Health Organization (WHO) Global Initiative for Emergency and Essential Surgical Care was established in 2005 to strengthen the delivery of surgical care in low-income countries.[4] WHO has defined the types of essential and emergency surgery that should be undertaken and the kind of surgical staff, infrastructure and supplies required in three levels of health-care facilities: level 1, small hospitals/health centres; level 2, district/provincial hospitals; and level 3, referral hospitals.[5,6] WHO has also proposed standardized metrics for global surgical surveillance.[7] Recent surveys suggest that essential resources are not in place in rural hospitals in low-income countries.[8–10]

Uganda, a low-income country, faces considerable challenges in the provision of paediatric surgical care. Of its rapidly-growing population of 31.7 million, 49% is under 15 years of age and 88% lives in rural areas. Uganda's population demographics, expenditure on health care and health-care outcomes are typical of low-income countries in sub-Saharan Africa.[11,12] Postgraduate training opportunities for physicians are limited; only 10 trainees complete postgraduate training in surgery in the country each year.

Whereas published surveys of surgical activity in sub-Saharan Africa have focused on single institutions,[2,3,13] this study is a regional survey of surgical activity and surgical facilities in all hospitals that were performing paediatric surgery in 2007–2008 in the south-western part of Uganda. Specific objectives were to determine the rates of surgery in children and adults and determine if the area's surgical facilities and surgical and anaesthesia workforce comply with published WHO standards for surgery.[5,6] England is a high-income country with a National Health Service that provides most of the health care for the population and where accurate data regarding surgical activity and workforce are collected. Comparisons were made between Uganda and England to gauge the magnitude of the differences in surgical activity and workforce between a high-income and a low-income country.

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(*Submitted: 7 February 2010 – Revised version received: 21 May 2010 – Accepted: 28 May 2010 – Published online: 7 June 2010*)

Methods

Between 6 October and 8 November 2008, we conducted a cross-sectional survey of the surgical and anaesthesia workforce and of the infrastructure and availability of drugs and equipment for surgery in all hospitals in south-western Uganda that were designated as centres for major surgery. We defined major surgery as any intervention occurring in a hospital operating theatre involving the incision, excision, manipulation or suturing of tissue and requiring regional or general anaesthesia or sedation.[1] We defined minor surgery as any procedure that did not require regional or general anaesthesia or sedation (e.g. dressing wounds, applying a cast or suturing lacerations under local anaesthesia). A retrospective review of the surgical workload was performed to calculate the surgical rates for children and adults during 2007–2008, and the rates of in-patient paediatric surgery were compared to corresponding rates in England during the same time period.[14]

Demographics

We estimated the total population of the south-western region of Uganda in 2007 by applying the WHO population growth rate of 3.2% per year after 2002 to population data for the 14 study districts from the 2002 Uganda Population and Housing Census.[12,15] Using data from the WHO Statistical Information Service, we calculated the number of children aged ≤ 14 years[12] to allow comparison with international data sets and previous observational studies in children.[2,12,14]

Survey sites

We surveyed all hospitals that had been designated as centres for major surgery in 14 districts of the Western and Central administrative regions of south-western Uganda (Kisoro, Kabale, Kanungu, Rukungiri, Ntungamo, Isingiro, Mbarara, Bushenyi, Kasese, Ibanda, Kiruhura, Kamwenge, Rakai and Masaka). We obtained the names of the hospitals from the 2001 Uganda Ministry of Health Inventory of Health Facilities[14] and from local residents.

Survey procedures

During the study period, two trained investigators (ADO, FM) visited the hospitals to interview staff and review the theatre logbooks for the period from 1 August 2007 to 31 July 2008. A data collection form was used to obtain a description of the hospital, the number of in-patient beds, the number of operating theatres in use, the types of operations performed, the number, speciality and training of surgeons on staff, and the number and training of anaesthesia providers on staff. A structured interview was devised to obtain information on facilities for anaesthesia from anaesthesia providers. The investigators were trained over a period of one week and pilot interviews were conducted at Mbarara University Hospital.

Survey analysis

We used simple descriptive statistics to summarize the data from hospitals where major surgery was performed. Any missing data were noted and whenever surgical activity data were missing, the weekly surgical rate was calculated and extrapolated to obtain the annual surgical rate for that facility. Facilities in hospitals performing major surgery were compared with recommended standards for WHO level-2 hospitals and with WHO guidelines on the infrastructure needed to support safe surgery.[5,6]

We analysed the major surgical workload in detail, compared the total surgical rate with global rates for surgery in different income settings,[1] and, whenever possible, described surgical services in light of WHO standardised metrics.[7] Surgical operations in children aged ≤ 14 years were categorized according to surgical diagnosis and their rates were compared with the surgical rates for children in England during the same time period using codes for finished consultant episodes.[2,14,16] The surgical and anaesthesia workforce was compared to that in England using the National Health Service Census.[17]

The research and ethics committees of the University of Mbarara and the Mbarara University Hospital approved the survey.

Results

Population and hospital characteristics

The population of the region was estimated at 6 305 000 and the population aged ≤ 14 years at 3 089 000 (49% of the total).[12]

All 72 hospitals in the region, 29 of which were performing major surgery, were visited (Table 1). This included 9 district hospitals, 3 referral hospitals, 1 private hospital and 12 hospitals belonging to missions or to nongovernmental organizations (NGOs). There were 47 Health Centres IV (HCIV), the lowest level of rural health centre designated to perform major surgery. Only 4 HCIV were performing major surgery at WHO level 2. Of the remaining 43 HCIV, 11 were performing no surgery at all and the others were performing only minor procedures not requiring anaesthesia due to inadequate staffing (anaesthetists or surgeons) or operating theatre equipment.

Operating room facilities

Detailed information was obtained from 28 of the 29 hospitals (97%) that performed major surgery (Table 2). We could not obtain this information from one hospital because the anaesthesia provider was not on site. None of the hospitals consistently met the standards for a WHO level 2 hospital in the previous three months, and only seven hospitals met this standard "sometimes." Mbarara University Hospital sometimes had the facilities recommended for a level 3 hospital. There were shortages of personnel, drugs, equipment and general facilities for surgery in all hospitals. Electricity and running water were not always available in 9 and 8 hospitals, respectively. Blood was not always available for transfusion in 18 hospitals.

Drawover anaesthesia (halothane or ether) was used in 26 hospitals, and oxygen was supplied in them by an electric oxygen concentrator. All hospitals indicated having a supply of oxygen in operating theatres at all times, although 9 hospitals did not have a backup generator for power failures, which are common in Uganda. Ketamine, the induction agent in most common use, was always available in 27 of the 28 hospitals. Anaesthesia providers indicated that the most important factors for improving anaesthesia delivery were modern anaesthesia equipment and monitoring. A pulse oximeter was available in 13 of the 28 hospitals, that is, 26 of 57 operating theatres; thus, the oximeter "gap" was 54%. Only two hospitals had a pulse oximeter and oxygen available in the theatre recovery area.

Workforce

There were 43 consultant specialist surgeons in the region (0.7 accredited surgeons per 100 000 population); specialities included general surgery, obstetrics,

Table 1. **Summary characteristics of 29 hospitals performing major surgery in 14 districts of south-western Uganda, 2007–2008**[a]

Designation of hospital	In-patient beds		Operating theatres in use		Surgeons in post						Anaesthesia providers in post							
					Specialist surgeon		Trainee surgeon		Medical officer		Physician anaesthetist		Anaesthetic officer		Anaesthetic assistant		"Trained on job"	
	No.	Median (range)	No.	Median (range)	No.	Median (range)	No.	Median (range)	No.	Median (range)	No.	Median (range)	No.	Median (range)	No.	Median (range)	No.	Median (range)
Government Health Centres IV[a] (n = 4)	142	32 (29–50)	6	1.5 (1–2)	0	–	0	–	5	1 (1–2)	0	–	1	0 (0–1)	4	1 (0–1)	0	–
Government district hospital (n = 9)	979	100 (100–150)	18	2 (2–2)	2	0 (0–1)	0	–	22	2 (1–5)	0	–	11	2 (0–2)	8	1 (0–2)	6	0 (0–3)
Government referral hospital (n = 3)	980	330 (200–450)	6	2 (2–2)	26	4 (2–20)	17	3 (3–11)	7	3.5 (2–5)	7	1 (0–6)	13	5 (3–5)	3	1 (0–2)	1	0 (0–1)
NGO/mission hospital[b] (n = 12)	1736	147 (25–300)	30	2 (1–4)	12	0 (0–4)	0	–	29	3 (2–5)	0	–	8	1 (0–2)	10	1 (0–2)	10	1 (0–4)
Private hospital (n = 1)	100	–	1	–	3	–	0	–	2	–	2	–	0	–	1	–	0	–
Totals for all 14 districts (n = 29)	**3937**	**100 (25–450)**	**61**	**2 (1–4)**	**43**	**0 (0–20)**	**17**	**0 (0–17)**	**65**	**2 (0–5)**	**9**	**0 (0–6)**	**33**	**1 (0–5)**	**26**	**1 (0–2)**	**17**	**0 (0–4)**
Total per 100 000 population	**62**	–	**1.0**	–	**0.7**	–	**0.3**	–	**1.0**	–	**0.1**	–		**0.9**[c]			**0.3**	–

NGO, nongovernmental organization.

[a] In 2007 the region had a population of 6 305 000.

[b] Anaesthesia administered by operating surgeon in two hospitals.

[c] Totals for anaesthetic officers and anaesthetic assistants combined.

orthopaedic surgery, ophthalmology, dental surgery, neurosurgery, ear, nose and throat surgery and urology. According to British National Health Service census data, England had 6260 consultant surgeons and 1506 consultant obstetricians and gynaecologists in 2007 (15.2 per 100 000 population).[16,17] In Uganda, the number of trained surgeons was 4.6% of what it was in England. Twenty-one surgeons worked in urban centres, either in the regional referral hospitals or in the private hospital (Table 1). There were no specialized paediatric surgeons in the region and only 62 general physicians (medical officers, 1.0 per 100 000 population) who performed surgery, mainly in the HCIVs and in district and mission hospitals. Of these medical officers, 32 were within 5 years of qualification and lacked specialist surgical training.

The region had 85 anaesthesia providers, only 9 of whom were physicians (7 consultants who had completed specialized training in anaesthesiology and 2 trainees). This amounted to 0.14 physician anaesthetists per 100 000 population, compared with 4791 consultant anaesthetists in England (9.3 per 100 000 population).[16,17] Thus, the number of consultant anaesthetists in Uganda was 1.4% the number in England. The remaining anaesthesia providers were 33 non-physician anaesthetic officers with 2 years of training, 26 anaesthetic assistants with 1 year of training, and 17 providers with no formal training ("trained on the job"). Thus, trained non-physician anaesthesia providers numbered 0.9 per 100 000 population, and accredited anaesthetists (physician and non-physician) numbered 1.1 per 100 000 population. In two hospitals anaesthesia was administered by the surgeon or by midwives or nurses.

Access to surgery

We analysed surgical logbooks in all hospitals, although Kabale Regional Referral Hospital had only 25 weeks of consecutive logbook data. Thus, for this hospital the annual surgical workload was extrapolated from the weekly rate. The reliability of the logbook data was confirmed by two members of the project team who worked in the region and by examining the dates and continuity of the entries. A total of 41 113 major operations were performed between 1 August 2007 and 31 July 2008 (equivalent to 652 per 100 000 population per year)(Table 3). Of all operations, 93% were performed in 18

Table 2. **Compliance with WHO standards for surgical workforce[a] and essential supplies and infrastructure[b] in hospitals performing major surgery in 14 districts of south-western Uganda, 2007**

Resource	Hospitals that always meet WHO standards for major surgery							
	Government Health Centres IV ($n=4$)		Government district hospitals ($n=8$[a] or $n=9$[b])		NGO/mission hospitals ($n=12$)		Government regional referral hospitals ($n=3$)	
	No.	%	No.	%	No.	%	No.	%
Personnel								
Trained surgeon (excluding medical officers)	0	0	3	33	8	67	3	100
Trained anaesthetist	3	75	9	100	10	83	3	100
Drugs								
Ketamine	4	100	8	100	12	100	2	67
Local anaesthetic	3	75	8	100	11	92	3	100
Thiopentone	1	25	5	63	10	83	1	3
Suxamethonium	1	25	4	50	11	92	3	100
Volatile agent	3	75	6	75	12	100	3	100
Opioid	3	75	3	38	12	100	1	33
Adrenaline	3	75	6	75	12	100	2	67
Vasoconstrictor	3	75	5	63	11	92	2	67
Anaesthetic equipment								
Child anaesthesia delivery system	3	75	8	100	11	92	3	100
Child facemask	3	75	8	100	12	100	3	100
Laryngoscope	3	75	7	88	12	100	3	100
Child laryngoscope	2	50	5	50	12	100	3	100
Pulse oximeter	0	0	2	25	8	67	3	100
Suction	2	50	6	75	12	100	3	100
Anaesthetic disposables								
Sterile gloves	2	50	8	100	11	92	1	33
Examination (non-sterile) gloves	2	50	3	38	6	50	0	0
Child oropharyngeal airway	3	75	5	63	10	83	2	67
Child tracheal tubes	1	25	6	75	12	100	3	100
Spinal needles	3	75	8	100	11	92	3	100
General facilities for emergency surgery								
Electricity (with backup generator)	1	25	5	63	11	100	2	100
Running water	3	75	4	50	9	75	3	100
Facilities to measure haemoglobin	3	75	5	63	8	67	1	33
Facilities to measure blood sugar	2	50	4	50	7	58	0	0
Blood for transfusion	1	25	2	25	4	33	2	67

NGO, nongovernmental organization; WHO, World Health Organization.

[a] Information on workforce obtained from 29 hospitals.

[b] Information on essential supplies and infrastructure obtained from 28 hospitals. The private hospital reached all standards except for sterile/non-sterile gloves (national shortage) and the recommended backup generator for the operating theatre.

hospitals (5 district hospitals, 3 regional referral hospitals and 10 mission/NGO hospitals); 45.4% of them were performed in government hospitals, 54.6% in mission/NGO hospitals and 0.5% in the private hospital. For comparison, Table 3 shows the mean estimated surgical rate in countries with poor, low, middle and high expenditure on health care.[1] Use of the operating room and staffing levels in different hospitals are shown in Table 4.

As shown in Table 3, 5571 operations were performed in children aged ≤ 14 years; the annual overall surgical rate for children was 180 per 100 000 population aged ≤ 14 years. During the same time period, the annual surgical rate for children aged ≤ 14 years in England was 5892 per 100 000. Thus, the paediatric surgical rate in Uganda was 3.0% of the rate in England.[16,17]

In Uganda (Table 5), the three most common diagnostic surgical categories in children were trauma and burns (30.2%), general or urologic paediatric surgery (25%), or infection (drainage of abscess/osteomyelitis) (14.9%). The surgical rate for cleft lip and palate repair was 21% of the rate in England. Cleft surgery was undertaken by plastic surgery teams from Kampala, Mbarara, the United Kingdom of Great Britain and Northern Ireland and Germany who operated in Mbarara or in rural hospitals. These surgeons received external funding from Smile Train and Interplast and performed 112 of the 140 (80%) operations for cleft lip and palate repair.

Outcomes

In-theatre outcomes were recorded for 5188 operations. Four children, all of whom had been recorded in the theatre logbooks as being in poor condition before surgery, died in theatre (in theatre

Table 3. **Surgical procedures performed in 29 hospitals performing major surgery in 14 districts of south-western Uganda, 1 August 2007 to 31 July 2008**[a]

Parameter	Surgical procedures					
	Children aged ≤14 years			All ages		
	No.	Median	Median range	No.	Median	Median range
Hospital designation						
Health Centres IV ($n=4$)	137	31.5	27–47	1 034	209	120–496
Government district hospital ($n=8$)	1 407	98.0	3–383	12 107	844	160–1152
Government referral hospital [b] ($n=3$)	969	324.0	261–338	5 330	1716	946–2668
NGO/mission hospital ($n=12$)	3 039	213.5	3–731	22 455	1585	92–6430
Private hospital ($n=1$)	19	–	–	187	–	–
Total[c]	**5571**	–	–	**41 113**	–	–
Overall surgical rate (no. per 100 000 population)	**180**	–	–	**652**	–	–
Estimated surgical rate (no. per 100 000 population)						
In poor expenditure countries, mean (SE)[1]					295 (53)	
In low-expenditure countries, mean (SE)[1]					2 255 (342)	
In middle-expenditure countries, mean (SE)[1]					4 248 (524)	
In high-expenditure countries, mean (SE)[1]					11 110 (1 300)	

NGO, nongovernmental organization; SE, standard error.

[a] The 2007 population estimates for the 14 regions of south-western Uganda were 6 305 000 for all ages and 3 089 000 for children aged ≤14 years. Surgical activity is reported from the 29 hospitals in the region where major surgery was undertaken.

[b] Data from 1 August 2007 to 22 January 2008 only were obtained from the Kabale regional referral hospital; the weekly surgical rate for that period was calculated and extrapolated to obtain the annual surgical rate for this hospital.

[c] Mean estimated surgical rates from reference[1]. Expenditure rates are adjusted to 2004 United States dollars (US$). Countries (including Uganda) were ranked by per capita total expenditure on health as follows: poor: US$ 100 or less; low: US$ 101–400; middle: US$ 401–1000; high: >US$ 1000.

mortality: 7.7 deaths per 10 000 cases). One was a 2-year-old with a delayed diagnosis of Hirschsprung's disease; two required burr holes after a head injury, and one was a 3-year-old who had inhaled a foreign body. Information about postoperative mortality was not available.

Discussion

We have described a comprehensive regional survey of health-care facilities providing major surgery for children in a low-income country. None of the hospitals in the region reliably achieved WHO standards for essential and emergency surgery. Deficiencies related to workforce, drugs, equipment and infrastructural factors such as electricity supply, running water and blood for transfusion. Disposable equipment was routinely reused or not available. We found that of a total of 29 hospitals that undertook major surgery, 18 performed 93% of all operations in the region. Furthermore, the nongovernment sector covered a large portion of the total surgical workload. Of a total of 47 rural health centres, only 4 could perform major surgery. Paediatric surgery was almost entirely of an emergency nature, mainly for burns and trauma. Externally funded surgeons performed an important fraction of all elective plastic and reconstructive surgical procedures.

One strength of our study is that it included all health-care facilities in the region where major surgery was performed. The Ugandan Ministry of Health requires that all surgical activity be recorded in

Table 4. **Operating room activity and staffing for 29 hospitals performing major surgery in 14 districts of south-western Uganda, 1 August 2007 to 31 July 2008**[a]

Designation of hospital	Procedures per operating room		Procedures per surgeon (excluding surgical interns)		Anaesthesia providers per operating room		Physician anaesthetists per operating room	
	Median	Range	Median	Range	Median	Range	Median	Range
Health centre IV	139	60–248	139	60–496	0.75	0–1	0	–
Government district hospital	367	80–3497	250	80–1748	1	0.5–2	0	0
Government referral hospital	667	473–858	158	133–572	2.75	1.7–3.5	0.5	0–1.5
NGO/mission hospital	612.5	46–2143	373	46–1460	0.6	0–1.5	0	0
Private hospital	62	–	37	–	1.3	–	1	–
All hospitals	**422**	**60–3497**	**226**	**60–1748**	**1**	**0–3.5**	**0**	**0–1.5**

NGO, nongovernmental organization.

[a] Activity of all surgeons aggregated.

the operating theatre logbook, and the project team is confident that the data was accurately recorded. One weakness, on the other hand, was that the data were collected retrospectively and the surgical activity for one hospital was extrapolated from 25 weeks of records covering the period from 1 August 2007 to 22 January 2008. We recommend that a more robust definition of major and minor surgery be developed for future surveys. In-theatre mortality was recorded in the theatre logbook for 97% of paediatric operations. This in-theatre mortality underestimates overall perioperative mortality because most deaths after surgery tend to occur in the ward, particularly in neonates. In-hospital deaths on the day of surgery and within 30 days of surgery should be routinely monitored.[7]

Nordberg et al. estimated that in sub-Saharan Africa, the basic public health requirement for major surgery is 1000 operations per 100 000 population annually.[18] The overall surgical rate found in this study approached this figure and was higher than previously estimated in Uganda, probably because other authors did not take the contribution of NGOs into consideration.[1,19] The Ugandan Government has recently upgraded HCIV facilities to improve access to essential surgery for the rural population.[20,21] In our study, most HCIV hospitals were performing little or no surgery due to lack of workforce or facilities. In contrast, mission/NGO hospitals in rural areas appeared to be better equipped and supplied (possibly due to their external funding and fee structure). They were the more efficient providers of surgical care in the region, performing 55% of all operations while using only 44% of the total number of hospital beds. Where resources are so critically limited, it may be advisable to improve transportation so that surgery can be concentrated in a limited number of government- or NGO-operated facilities.

This study showed that the rate of inpatient surgical procedures in children in Uganda was very low and a mere 3% of the rate seen in England. Although there are obvious socioeconomic differences between the two countries, the comparison highlights the vast underprovision of elective paediatric surgery in Uganda. Furthermore, the study confirmed the findings of previous studies performed in single institutions, namely that delayed presentation for surgery was common and that preventable conditions, such as burns and trauma or the complications of infectious processes, accounted for much of the surgery in children.[2,22] Many basic paediatric operations (both elective and emergency in nature) were performed by medical officers, many of whom lacked specialist surgical training. The situation poses a challenge for countries where a rural medical officer is expected to cover medical, surgical and obstetric care. A previous report from Nigeria recorded a single paediatric surgeon for a population of approximately 2 million (by comparison, Europe has one paediatric surgeon per 50 000 population).[23,24]

No specialist paediatric surgeons were identified in the south-western region of Uganda. Higher surgical rates were found where visiting surgeons funded by external organisations, such as Smile Train or Interplast, performed specialist surgery.[25,26] These teams bring specialist skills to rural populations, and they are also able to purchase additional drugs, equipment and monitoring to defined standards so that complex procedures can be undertaken safely.[26]

Task-shifting is often seen as a potential solution to the medical workforce crisis.[27,28] Our finding that 17 anaesthesia providers were "trained on the job" indicates too much reliance on task-shifting to untrained personnel. Although the development of the non-medical workforce has proved essential in increasing the delivery of care, quality standards have not been maintained in rural areas.[4–6]

In-theatre mortality in children in south-western Uganda (7.7 deaths per 10 000 operations) was lower than anticipated and less than the in-theatre mortality reported for specialist children's facilities in middle- and high-income countries (9.8, 3.46 and 0.4 deaths per 10 000 operations in institutions in Pakistan, Brazil and France, respectively).[29–31] This may be partly explained by differences in case mix, since the cases in Uganda were less complex. Very high perioperative mortality rates have been reported for adults and children in hospitals in low-income countries, where many avoidable deaths have been associated with failures in administrative procedures, anaesthesia and surgical care.[32–37] These studies have included deaths on the wards up to 6 days postoperatively and have shown perioperative mortality rates of 26 to 257 deaths per 10 000 operations, as well as anaesthesia complications frequently related to failures in airway management (including tracheal intubation), respiratory monitoring and in reversing paralysis after anaesthesia.[33–37] Children who undergo surgery in Uganda are frequently given ketamine, an effective and safe anaesthetic and analgesic agent, and since ketamine generally preserves airway patency, it is often used without tracheal intubation or paralysis. Because of these attributes, non-anaesthetists in emergency departments in advanced countries are using ketamine in increasing numbers.[38] It is possible that ketamine-based anaesthesia without tracheal intubation provides relatively safe conditions for simple surgery in children in Uganda and similar settings.

Meeting the needs for safe surgical care in a low-income country such as Uganda, where resources are few, is a complex matter. It calls for investing in hospital facilities, supplies of drugs and disposable items. The low numbers of medical graduates, limited opportunities for postgraduate training and medical migration limit the available workforce.[39–41] Expansion of in-country postgraduate training opportunities with external support and funding may eventually lead to self-sufficiency.[21,42,43] Local clinicians can benefit from the valuable training opportunity offered by partnering with visiting specialists.[21,25,44] Task shifting has been suggested as a solution to workforce shortages in some areas, but support and supervision are needed to maintain the standards of care.[27,28] Although many anaesthesia providers in our study expressed the wish to have modern anaesthesia machines, this may not be feasible at present due to infrastructural limitations (reliance on electricity, pressurised oxygen supply and sophisticated maintenance). No ISO standard exists at present for an anaesthesia machine suited to low-income countries,[45] and we urge manufacturers to consider designing anaesthesia delivery systems specifically for these regions.

Surgery is an essential component of public health, and surgical facilities must meet certain basic standards for safe practice. According to our survey, in Uganda large volumes of surgery are handled by a small number of hospitals and an important fraction of all operations is performed in mission/NGO hospitals

Table 5. **Surgical conditions in children aged ≤14 years in 29 hospitals[a] performing major surgery in 14 districts of south-western Uganda, 1 August 2007 to 31 July 2008**

Diagnosis	Procedures		Age (years)	
	No.	%	Median	Range
Trauma and burns				
Wound requiring surgical debridement	1201	22.42	7	0.03–14
Burn/contracture	215	4.01	4	0.2–14
Laceration	54	1.0	7.5	0.25–14
Lesion requiring amputation (unspecified)	53	0.99	8	0.4–14
Fracture requiring surgical intervention	48	0.90	3.5	0.02–14
Soft tissue trauma	18	0.34	10	0.9–14
Head injury	9	0.17	6	0.2–13
Snake bite	3	0.06	10	0.3–12
Abdominal trauma	2	0.04	5.5	3–8
Fracture necrosis	1	0.02	12	–
Other	15	0.28	8	0.01–13
Subtotal	**1619**	**30.22**	**7**	**0.03–14**
Congenital anomalies				
Hernia (inguinal, umbilical)	479	8.94	4	0.008–14
Cleft lip and palate	140	2.61	2	0.1–14
Minor anomalies (tongue tie/extra digit)	87	1.62	0.5	0.003–10
Club foot	25	0.47	5	0.75–14
Undescended testis	18	0.34	5	0.75–14
Anorectal abnormality	23	0.43	0.1	0.03–9
Meningomyelocoele	9	0.17	0.005	0.003–0.02
Hirschsprung's disease	7	0.13	2	0.01–4
Hypospadias	3	0.06	1	0.25–4
Omphalocoele	3	0.06	0.02	0.008–0.06
Cystic hygroma	2	0.04	8	3–13
Subtotal	**796**	**14.86**	**5**	**0.008–14**
Surgical infections				
Abscess	687	12.82	3	0.05–14
Osteomyelitis	67	1.25	9	0.8–14
Septic arthritis	16	0.30	2	0.07–13
Empyema	7	0.13	6	3.5–13
Pyomyositis	5	0.09	4	1–12
Cellulitis	5	0.09	1	0.04–13
Other	12	0.22	4.25	0.01–14
Subtotal	**799**	**14.91**	**3.5**	**0.005–14**
General paediatric surgery and urology				
Phimosis/social circumcision	610	11.39	2.5	0.003–14
Intra-abdominal condition requiring laparotomy	249	4.63	7	0.008–14
Superficial lesion requiring excision	134	2.50	8	0.08–14
Neoplasm – excision/biopsy	52	0.97	8	0.02–14
Intussusception	22	0.41	0.7	0.17–14
Appendicitis	5	0.09	8	5–13
Rectal prolapse	12	0.22	2.5	0.17–10
Thyroid mass	2	0.04	9.5	5–14
General surgery other	126	2.35	7	0.003–14
Bladder stone	3	0.06	3	1–12
Urinary retention	1	0.02	14	–
Other urology	100	1.87	6	0.003–14
Gynaecological cases	22	0.41	1.4	0.04–14
Subtotal	**1338**	**24.99**	**5**	**0.003–14**
Ear, nose and throat				
Foreign body (unspecified)	241	4.50	4	0.2–14
Tonsillectomy	26	0.49	7	1.6–13
Inhaled foreign body	2	0.04	3	0.33–11
Other	5	0.09	9	0.3–13
Subtotal	**274**	**5.11**	**4**	**0.2–14**
Neurosurgical				
Intracranial lesion requiring craniotomy	**1**	**0.02**	**7**	–
Orthopaedic surgery	**150**	**2.80**	**7**	**0.08–14**
Pregnancy related				
Caesarean section (unspecified indication)	23	0.43	14	12–14
Retained products of conception	9	0.17	14	14–14
Subtotal	**32**	**0.60**	**14**	**12–14**
Ophthalmological cases	**348**	**6.50**	**6**	**0.2–14**
Total all cases	**5357**	**100**	**5**	**0.003–14**

[a] Data from 1 August 2007 to 22 January 2008 only were obtained from the Kabale regional referral hospital.

and by visiting surgical teams. To address these problems and improve outcomes, steps must be taken to encourage surgical training in the country, retain the workforce and improve access to surgery and anaesthesia services. Maximizing the use of resources by strengthening services in a limited number of centres, whether run by the government or by missions or NGOs, would seem to be a sensible approach. ■

Funding: This study was funded by a grant from the Association of Anaesthetists of Great Britain and Ireland and the Association of Paediatric Anaesthetists of Great Britain and Ireland. The funding sources had no role in the design, conduct or reporting of the study.

Competing interests: IHW is a member of the WHO/WFSA Global Pulse Oximetry Project management group.

ملخص

جراحة وتخدير طب الأطفال في جنوب غرب أوغندا: مسح المقطع العرضي

الغرض: دراسة معدلات جراحة طب الأطفال في جنوب غرب أوغندا، ومقارنتها مع معدلات إنكلترا، وتحديد مقدار تلبية الخدمات الجراحية المتوفرة والقوة العاملة فيها لمعايير منظمة الصحة العالمية.

الطريقة: لجمع المعلومات عن الخدمات الجراحية والقوة العاملة فيها، أجرى الباحثون مسح المقطع العرضي لجميع المستشفيات التي تجري جراحات كبرى في 14 مقاطعة في جنوب غرب أوغندا في العامين 2007-2008. وباستخدام بيانات سجل الأداء، حدد الباحثون المعدلات الجراحية، وأنواع الجراحات، ونتائج غرف العمليات.

الموجودات: من 72 مستشفى جرى مسحها، وجد أن 29 مستشفى كانت تقوم بجراحات كبرى. ولم تلبي أي مستشفى معايير منظمة الصحة العالمية للجراحة الأساسية. وكان هناك 7 جراحين معتمدين لكل مئة ألف نسمة، ولم يوجد جراحون مختصون في طب الأطفال. وأغلب تقنيّ التخدير لم يكونوا أطباء (وبلغ عدد تقنيّ التخدير المعتمدين 1.1 لكل مئة ألف نسمة).

ومعدل الجراحة السنوي للأطفال البالغ عمرهم أقل من أو يساوى 14 سنة كان 180 عملية جراحية لكل مئة ألف نسمة؛ وكانت أغلبها جراحات طارئة. وكان معدل الجراحة السنوي للمرضى من جميع الأعمار هو 652 عملية جراحية لكل مئة ألف نسمة، وبلغ الوسيط الإحصائي 422 عملية لكل غرفة عمليات (والمجال: 60-3497) و 226 عملية لكل جراح (المجال: 60-1748). وقد أجرت مستشفيات الإرساليات ومستشفيات المنظمات غير الحكومية، واللتان تضمان معاً 44% من أسرة المستشفيات في المنطقة، 3039 علمية جراحية لطب الأطفال (بنسبة 55%). وأجرى الجراحون المموَّلون من الخارج 80% من 140 عملية لمعالجة الشفة المشقوقة والفلح الحنكي. ووقعت أربع وفيات في غرف العمليات بين الأطفال في عمر أقل من أو يساوي 14 سنة (وبلغ معدل الوفيات في غرف العمليات: 7.7 وفاة لكل مئة ألف نسمة).

الاستنتاج: إن مستوى الوصول إلى جميع الجراحات، بما في ذلك جراحات طب الأطفال، سيء في لألفألف

جنوب غرب أوغندا، وهناك حاجة ملحة للاستثمار في خدمات الرعاية الصحية الأساسية والتدريب والقوة العاملة في الجراحة. وتساهم مستشفيات الإرساليات ومستشفيات المنظمات غير الحكومية إسهاماً قيّما في الجراحات التخصصية. وكان معدل الوفيات في غرف العمليات أقل من المعدلات المبلغ عنها في المواقع المشابهة لهذا الموقع.

Resumé

Anesthésie et chirurgie pédiatriques dans le Sud-ouest de l'Ouganda: une étude transversale

Objectif Étudier les taux de chirurgie pédiatrique dans le ud-ouest de l'Ouganda, puis les comparer aux taux en Angleterre et déterminer si les installations et les effectifs chirurgicaux existants répondent aux normes de l'Organisation mondiale de la Santé (OMS).

Méthodes Pour obtenir des informations sur les installations et les effectifs en matière de chirurgie, nous avons mené une étude transversale sur l'ensemble des hôpitaux effectuant des actes chirurgicaux majeurs dans 14 districts du Sud-ouest de l'Ouganda en 2007–2008. Par le biais des données des registres des blocs opératoires, nous avons déterminé les taux et les types de chirurgie pratiquée, ainsi que les résultats chirurgicaux en salle d'opération.

Résultats Sur 72 hôpitaux étudiés, 29 pratiquaient des actes chirurgicaux majeurs. Aucun d'entre eux ne respectait les normes de l'OMS en matière de chirurgie fondamentale. On comptait 0,7 chirurgien accrédité pour 100 000 habitants et aucun chirurgien pédiatrique. La majorité des anesthésistes n'étaient pas médecins (nombre d'anesthésistes accrédités pour 100 000 habitants: 1,1).

Le taux de chirurgie annuel pour les enfants âgés de moins de 14 ans était de 180 opérations pour 100 000 habitants, la plupart étant des interventions d'urgence. Le taux de chirurgie annuel pour les patients tous âges confondus était de 652 opérations pour 100 000 habitants, avec une moyenne de 422 opérations par salle opératoire (fourchette: 60–3 497) et de 226 opérations par chirurgien (fourchette: 60–1 748). Les hôpitaux des missions ou des organisations non gouvernementales (ONG), soit 44% des lits de la région, ont effectué 3 039 opérations pédiatriques (55%). Les chirurgiens subventionnés par l'étranger ont effectué 80% des 140 interventions de palais fendu et de bec-de-lièvre. Quatre décès en salle d'opération ont été recensés chez des enfants âgés de moins de 14 ans (mortalité en cours d'intervention chirurgicale: 7,7 décès pour 10 000 opérations).

Conclusion L'accès à tous les actes chirurgicaux, y compris à la chirurgie pédiatrique, est médiocre dans le sud-ouest ougandais. De plus, il est urgent d'investir dans des installations sanitaires de base, de recruter du personnel chirurgical et de le former. Les hôpitaux des missions et des ONG contribuent largement à la chirurgie élective, et les chirurgiens subventionnés par l'étranger interviennent quant à eux de façon importante dans la chirurgie spécialisée. La mortalité en cours d'intervention chirurgicale était inférieure aux chiffres annoncés dans d'autres configurations similaires.

Resumen

Cirugía y anestesia pediátricas en el Sudoeste de Uganda: un estudio transversal

Objetivo Estudiar las tasas de intervenciones quirúrgicas pediátricas en el Sudoeste de Uganda, compararlas con las tasas de Inglaterra (Reino Unido) y determinar si las instalaciones y el personal quirúrgico existentes cumplen las pautas de la Organización Mundial de la Salud (OMS).

Métodos Para obtener información sobre las instalaciones y el personal quirúrgicos, se realizó un estudio transversal de todos los hospitales que realizaban intervenciones de cirugía mayor en 14 distritos del Sudoeste de Uganda entre 2007 y 2008. Gracias a los datos del cuaderno de registro de quirófano pudimos determinar los índices de cirugías, los tipos de intervenciones quirúrgicas llevadas a cabo y los resultados internos del quirófano.

Resultados De los 72 hospitales estudiados, 29 realizaron intervenciones de cirugía mayor. Ninguno cumplía las pautas de la OMS para las intervenciones quirúrgicas esenciales. El número de cirujanos acreditados por cada 100 000 habitantes fue de 0,7 y no había cirujanos pediátricos. La mayoría de los anestesistas no eran médicos (anestesistas acreditados por cada 100 000 habitantes: 1,1).

El índice anual de intervenciones quirúrgicas realizadas en niños de hasta 14 años fue de 180 operaciones por cada 100 000 habitantes, siendo en su mayoría procedimientos de urgencia. El índice anual de intervenciones quirúrgicas realizadas en pacientes de todas las edades fue de 652 operaciones por cada 100 000 habitantes, con una media de 422 intervenciones por quirófano (intervalo: 60-3497) y de 226 operaciones por cirujano (intervalo: 60-1748). Los hospitales de las misiones o de organizaciones no gubernamentales (ONG), que contaban con el 44% de las camas hospitalarias de la región, realizaron 3039 (55%) de las operaciones pediátricas. Los cirujanos financiados externamente realizaron el 80% de las 140 intervenciones de labio leporino y de fisura palatina. En el quirófano fallecieron cuatro niños ≤ 14 años (mortalidad en quirófano: 7,7 fallecimientos por cada 10 000 intervenciones quirúrgicas).

Conclusión El acceso en el Sudoeste de Uganda a todas las intervenciones quirúrgicas, incluyendo la cirugía pediátrica, es deficiente, por lo que se requiere una inversión urgente en instalaciones sanitarias básicas, así como personal y formación quirúrgica. Los hospitales de las misiones y de las ONG están realizando una valiosa contribución a la cirugía programada y los cirujanos pagados con fondos externos están contribuyendo de manera importante a la cirugía especializada. La mortalidad en quirófano fue inferior a la notificada en ámbitos similares.

References

1. Weiser TG, Regenbogen SE, Thompson KD, Haynes AB, Lipsitz SR, Berry WR et al. An estimation of the global volume of surgery: a modelling strategy based on available data. *Lancet* 2008;372:139–44. doi:10.1016/S0140-6736(08)60878-8 PMID:18582931
2. Bickler SW, Telfer ML, Sanno-Duanda B. Need for paediatric surgery care in an urban area of The Gambia. *Trop Doct* 2003;33:91–4. PMID:12680542
3. Bickler SW, Rode H. Surgical services for children in developing countries. *Bull World Health Organ* 2002;80:829–35. PMID:12471405
4. World Health Organization. Global initiative for emergency and essential surgical care [Internet site]. Geneva: WHO. Available from: http://www.who.int/surgery/globalinitiative/en/ [accessed 17 December 2009].
5. World Health Organization. *Integrated management for emergency and essential surgical care (IMEESC) toolkit*. Geneva: WHO. Available from: http://www.who.int/surgery/publications/imeesc/en/index.html [accessed 17 December 2009].
6. World Health Organization. *WHO gidelines for safe surgery: 2009: Safe surgery saves lives*. Geneva: WHO; 2009.
7. Weiser TG, Makary MA, Haynes AB, Dziekan G, Berry WR, Gawande AA; Safe Surgery Saves Lives Measurement and Study Groups. Standardised metrics for global surgical surveillance. *Lancet* 2009;374:1113–7. doi:10.1016/S0140-6736(09)61161-2 PMID:19782877
8. Hodges SC, Mijumbi C, Okello M, McCormick BA, Walker IA, Wilson IH. Anaesthesia services in developing countries: defining the problems. *Anaesthesia* 2007;62:4–11. doi:10.1111/j.1365-2044.2006.04907.x PMID:17156220
9. Mbonye AK, Mutabazi MG, Asimwe JB, Sentumbwe O, Kabarangira J, Nanda G et al. Declining maternal mortality ratio in Uganda: priority interventions to achieve the Millennium Development Goal. *Int J Gynaecol Obstet* 2007;98:285–90. doi:10.1016/j.ijgo.2007.05.019 PMID:17617415
10. Ouro-Bang'na Maman A-F, Kabore RAF, Zoumenou E, Gnassingbé K, Chobli M. Anesthesia for children in Sub-Saharan Africa–a description of settings, common presenting conditions, techniques and outcomes. *Paediatr Anaesth* 2009;19:5–11. doi:10.1111/j.1460-9592.2008.02838.x PMID:19076495
11. The World Bank. *Data and statistics*. Washington: WB; 2010. Available from: http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,contentMDK:20535285~menuPK:1192694~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html [accessed 17 December 2009].
12. World Health Organization. WHO Statistical Information System (WHOSIS) [Internet site]. Geneva: WHO. Available from: http://apps.who.int/whosis/database/menu.cfm?path=whosis,evidence,whosis,evidence,whosis&language=english [accessed 17 December 2009].
13. Bickler SW, Sanno-Duanda B. Epidemiology of paediatric surgical admissions to a government referral hospital in the Gambia. *Bull World Health Organ* 2000;78:1330–6. PMID:11143193
14. The Information Centre for Health and Social Care. Hospital episode statistics. Total procedures and interventions, 2007–08 [Internet site]. Available from: http://www.hesonline.nhs.uk/Ease/servlet/ContentServer?siteID=1937&categoryID=210 [accessed 17 December 2009].
15. Uganda Bureau of Statistics. *The 2002 Uganda population and housing census, population size and distribution*. Kampala: UBS; 2006. Available from: http://www.ubos.org/onlinefiles/uploads/ubos/pdf%20documents/2002%20CensusPopnSizeGrowthAnalyticalReport.pdf [accessed 17 December 2009].
16. Office for National Statistics. *Key population and vital statistics* (Series VS No. 34, PPI No. 30). Newport: ONS; 2009. Available from: http://www.statistics.gov.uk/downloads/theme_population/KPVS34-2007/KPVS2007.pdf [accessed 17 December 2009].
17. The Information Centre. *NHS hospital and community health services: medical and dental workforce census. England 30 September 2007*. Leeds: TIC; 2008. Available from: http://www.ic.nhs.uk/webfiles/publications/nhsstaff2007/med%20and%20den/Revised%20Med%20and%20Den%20Detailed%20Results%2007%2004-04-08.pdf [accessed 17 December 2009].
18. Nordberg E, Mwobobia I, Muniu E. Major and minor surgery output at district level in Kenya: review and issues in need of further research. *Afr J Health Sci* 2002;9:17–25. PMID:17298142
19. Nabembezi JS, Nordberg E. Surgical output in Kibaale district, Uganda. *East Afr Med J* 2001;78:379–81. PMID:11957265
20. Government of Uganda, Ministry of Health. *National health policy: reducing poverty through promoting people's health*. Kampala: MOH; 2009. Available from: http://www.health.go.ug/National_Health.pdf [accessed 17 December 2009].
21. Ozgediz D, Galukande M, Mabweijano J, Kijjambu S, Mijumbi C, Dubowitz G et al. The neglect of the global surgical workforce: experience and evidence from Uganda. *World J Surg* 2008;32:1208–15. doi:10.1007/s00268-008-9473-4 PMID:18299920

22. Thanni LO, Shonubi AMO, Akiode O. A retrospective audit of paediatric surgical admission in a sub-urban tertiary hospital. *West Afr J Med* 2005;24:10–2. PMID:15909702
23. Ameh EA, Adejuyigbe O, Nmadu PT. Pediatric surgery in Nigeria. *J Pediatr Surg* 2006;41:542–6. doi:10.1016/j.jpedsurg.2005.11.053 PMID:16516632
24. Driller C, Holschneider AM. Training in pediatric surgery–a comparison of 24 countries in Europe and other countries around the world. *Eur J Pediatr Surg* 2003;13:73–80. doi:10.1055/s-2003-39590 PMID:12776236
25. Hodges S, Wilson J, Hodges A. Plastic and reconstructive surgery in Uganda –10 years experience. *Paediatr Anaesth* 2009;19:12–8. doi:10.1111/j.1460-9592.2008.02839.x PMID:19076496
26. Smile Train. Available from: http://www.smiletrain.org/site/PageServer [accessed 19 December 2009].
27. World Health Organization. *Task shifting: global recommendations and guidelines.* Geneva: WHO; 2006.
28. McPake B, Mensah K. Task shifting in health care in resource-poor countries. *Lancet* 2008;372:870–1. doi:10.1016/S0140-6736(08)61375-6 PMID:18790295
29. Ahmed A, Ali M, Khan M, Khan F. Perioperative cardiac arrests in children at a university teaching hospital of a developing country over 15 years. *Paediatr Anaesth* 2009;19:581–6. doi:10.1111/j.1460-9592.2009.02992.x PMID:19645976
30. Gobbo Braz L, Braz JR, Módolo NS, do Nascimento P, Brushi BA, Raquel de Carvalho L. Perioperative cardiac arrest and its mortality in children. A 9-year survey in a Brazilian tertiary teaching hospital. *Paediatr Anaesth* 2006;16:860–6. PMID:16884469
31. Murat I, Constant I, Maud'huy H. Perioperative anaesthetic morbidity in children: a database of 24,165 anaesthetics over a 30-month period. *Paediatr Anaesth* 2004;14:158–66. doi:10.1111/j.1460-9592.2004.01167.x PMID:14962332
32. Walker IA, Wilson IH. Anaesthesia in developing countries–a risk for patients. *Lancet* 2008;371:968–9. doi:10.1016/S0140-6736(08)60432-8 PMID:18358913
33. Heywood AJ, Wilson IH, Sinclair JR. Perioperative mortality in Zambia. *Ann R Coll Surg Engl* 1989;71:354–8. PMID:2604342
34. McKenzie AG. Mortality associated with anaesthesia at Zimbabwean teaching hospitals. *S Afr Med J* 1996;86:338–42. PMID:8693367
35. Hansen D, Gausi SC, Merikebu M. Anaesthesia in Malawi: complications and deaths. *Trop Doct* 2000;30:146–9. PMID:10902471
36. Glenshaw M, Madzimbamuto FD. Anaesthesia associated mortality in a district hospital in Zimbabwe 1994-2001. *Cent Afr J Med* 2005;51:38–44.
37. Ouro-Bang'na Maman AF, Tomta K, Ahouangbévi S, Chobli M. Deaths associated with anaesthesia in Togo, West Africa. *Trop Doct* 2005;35:220–2. doi:10.1258/004947505774938666 PMID:16354475
38. Atkinson P, Chesters A, Heinz P. Pain management and sedation for children in the emergency department. *BMJ* 2009;339(oct30 1):b4234. doi:10.1136/bmj.b4234 PMID:19880530
39. Dambisya YM. The fate and career destinations of doctors who qualified at Uganda's Makerere Medical School in 1984: retrospective cohort study. *BMJ* 2004;329:600–1. doi:10.1136/bmj.38134.524387.AE PMID:15297304
40. World Health Organization. *Working together for health: the world health report 2006.* Geneva: WHO; 2006.
41. Eastwood JB, Conroy RE, Naicker S, West PA, Tutt RC, Plange-Rhule J. Loss of health professionals from sub-Saharan Africa: the pivotal role of the UK. *Lancet* 2005;365:1893–900. doi:10.1016/S0140-6736(05)66623-8 PMID:15924988
42. Zijlstra EE, Broadhead RL. The College of Medicine in the Republic of Malawi: towards sustainable staff development. *Hum Resour Health* 2007;5:10. doi:10.1186/1478-4491-5-10 PMID:17433100
43. Walker IA. Con: pediatric anesthesia training in developing countries is best achieved by out of country scholarships. *Paediatr Anaesth* 2009;19:45–9. doi:10.1111/j.1460-9592.2008.02844.x PMID:19076504
44. Wright IG, Walker IA, Yacoub MH. Specialist surgery in the developing world: luxury or necessity? *Anaesthesia* 2007;62(Suppl 1):84–9. doi:10.1111/j.1365-2044.2007.05308.x PMID:17937722
45. International Organization for Standardization. TC 121/SC1 Breathing attachments and anaesthetic machines [Internet site]. Geneva: IOS. Available from: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_tc_browse.htm?commid=51986&development=on [accessed 19 April 2010].