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DEVELOPMENT OF A RATIO OF EMERGENT TO TOTAL HERNIA REPAIRS AS A SURGICAL CAPACITY METRIC

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Summary

INTRODUCTION—Non-communicable diseases including surgical conditions are gaining attention in developing countries. Despite this there are few metrics for surgical capacity. We hypothesized that (a) the ratio of emergent to total hernia repairs (E/TH) would correlate with per capita health care expenditures for any given country, and (b) the E/TH is easy to obtain in resource-poor settings.

METHODS—We performed a systematic review to identify the E/TH for as many countries as possible (Prospero registry CRD42013004645). We screened 1285 English language publications since 1990; 23 met inclusion criteria. Primary data was also collected from Kamuzu Central Hospital (KCH) in Lilongwe, Malawi. A total of 13 countries were represented. Regression analysis was used to determine the correlation between per capita healthcare spending and the E/TH.

RESULTS—There is a strong correlation between the log values of the ratio emergent to total groin hernias and the per capita health care spending that is robust across country income levels (R^2=0·823). Primary data from KCH was easily obtained and demonstrated a similar correlation.

CONCLUSIONS—The ratio of emergent to total groin hernias is a potential measure of surgical capacity using data that is easily attainable. Further studies should validate this metric against other accepted health care capacity indicators.

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Introduction

Non-communicable diseases are gaining more attention as a cause of morbidity and mortality in developing countries.(1) Surgical conditions are included in this category, as they disproportionately affect low-income countries.(2) Basic surgical services are also traditionally viewed as prohibitively expensive, but in reality considerable evidence suggests that improving surgical care may result in significant gains in health with minimal expense. (3)

Surgical care in low and middle income countries (LMIC) continues to gain attention from the developed world.(4) There is a consensus that we have yet to resolve the critical shortcoming of surgical capacity in LMICs.(5) Despite this, there are few metrics available to quantify surgical capacity. We broadly defined the construct of surgical capacity as the ability of a health care system to meet the needs of its population. With the exception of injury, the commonly accepted national health indicators fail to provide assessments of surgical capacity. The World Health Organization (WHO) global health indicators typically report many variables pertinent to overall health (such as life expectancy and mortality, health expenditure, and demographic and socioeconomic statistics), infectious diseases (selected infectious diseases such as HIV/AIDS, tuberculosis and diarrheal diseases), infant and early childhood mortality and women's health (for example family planning, antenatal care coverage and maternal mortality).(6)

Despite the failure to include measures of surgical disease related morbidity and mortality in the WHO global health indicators, there are several published methods of assessing surgical capacity. Some proposed approaches involve many variables such as the Personnel, Infrastructure, Procedures, Equipment, and Supplies (PIPES) tool and the WHO Emergency and Essential Surgical Care (EESC) assessment tool.(7, 8) The most studied single metric, the ratio of Cesarean deliveries to total surgical cases (C/O), was proposed as a simple proxy for assessing surgical capacity. Several studies validate this ratio: developed countries have a lower C/O ratio compared to developing countries;(9) in Haiti the C/O ratio decreased as surgical capacity increased.(10) Though the C/O ratio appears to reflect surgical capacity it has several limitations including confounding by differences between countries in both birth rate and Cesarean section rates as a proportion of total births.(11) Some providers perform both obstetric and general surgical care, especially at rural or district hospital settings. In these settings the C/O ratio will function well. However, there are additional limitations of such a hybrid indicator. First, development leads to further specialization making specialty- or disease-specific indicators more useful. Second, interventions specific to either obstetrics or to general surgery will be difficult to measure using the C/O ratio.

We sought to identify a method of assessing surgical capacity. Worldwide the commonest general surgical condition is that of groin hernias (inguinal and femoral hernias). Procedures for groin hernias are common at Kamuzu Central Hospital (KCH), where the co-authors participate in a surgical partnership between KCH and the University of North Carolina. The co-authors also noted a surprisingly high rate of emergent procedures for groin hernias, which further prompted interest in groin hernias as a metric for surgical capacity. We hypothesized that Malawi would have a high ratio of emergent to total hernia repairs (E/

TH), and that across countries E/TH would correlated with common health statistics. Therefore the aims of this paper were to (a) describe the prevalence of elective and emergent surgery for hernias at KCH, and (b) evaluate E/TH as a metric for surgical capacity by comparing the E/TH for Malawi and other countries to per capita health care spending.

Methods

The surgical log for Kamuzu Central Hospital during the calendar year 2009 was reviewed. Kamuzu Central Hospital is a 1000 bed government hospital that is a tertiary referral center for about 5 million persons. The hospital has 4 major operating rooms, and the Surgery Department annually has about 4,500 admissions and performs around 2,000 cases. Among adults (age 16 or older), descriptive statistics were calculated for the total number of cases and the number of elective and emergent groin hernia cases. Cases were also classified as primary or recurrent, direct or indirect, femoral or inguinal, and by affected side.

Our systematic review utilized PubMed searching for English language studies published between 1990 and 2013 using the term “emergency hernia”. Publications reporting results of randomized controlled trials, those limited to pediatric or elderly populations, and those limited to femoral or incisional hernias were excluded, first using title only (N=1246), with the remaining then reviewed in full text (excluding an additional 23 studies). The reference lists of those meeting criteria after full text review were then checked to identify any additional studies. Data was abstracted and checked by two authors. If multiple publications were found for one country, values were averaged. The ratio was selected based on the following priority: groin hernias (femoral and inguinal hernias), inguinal hernias and lastly, external hernias (femoral, inguinal and ventral hernias). Some but not all studies included recurrent hernias, thus to minimize this source of heterogeneity we limited our analysis to non-recurrent hernias. The protocol for this systematic review was registered with Prospero (registered on 20 May 2013; CRD42013004645).

For each country, E/TH was compared to country-wide economic and health indicators (per capita expenditures on healthcare and World Bank country income level). Per capita expenditures on healthcare were expressed in 2009 US dollars. World bank country income levels (per capita gross national income) were expressed as low-income country (LIC; less than $4035), Low middle-income country (L-MIC; $4036-$4085), high middle-income country (H-MIC; $4086-$12615) and high-income country (HIC; greater than $12615).(12) The R^2 correlation statistic was used to calculate the correlation between the actual and the log values for per capita health care expenditure and E/TH for each country.

Analysis of dependent variable residual plots was used to identify the model with the least heteroscedasticity.

Ethics approval for the analysis of data from Malawi was obtained from the Institutional Review Board at the University of North Carolina and the National Health Sciences Review Committee of Malawi.

Results

In 2009, there were 219 adult groin hernia surgeries performed at Kamuzu Central Hospital in Lilongwe, Malawi. Of these, 88 were emergent. The total number of operations during the study period was 1956. Of the 219 groin hernias, 212 were indirect inguinal hernias, five were femoral hernias, and two were direct inguinal hernias. There were four recurrent hernias, and all five of the femoral hernias were operated on emergently. Of the indirect inguinal hernias, 123 were right-sided, 62 left-sided, seven bilateral, and 25 unspecified.

The initial search in Pubmed between 1990 and 2013 using the term “emergency hernia” identified 1285 publications. Initial screening for exclusion utilizing only titles excluded 1246 publications, and of the remaining 39 the full text was reviewed and an additional 23 were excluded. Sixteen publications thus met criteria, and after reviewing the reference lists of these 16 studies, an additional seven studies were identified. The total number of publications included was therefore 23 (figure 1; table 1).(13-35) After averaging data from publications from the same country and inclusion of the primary data from Malawi, 13 countries were included in the analysis, including four LICs (Malawi, Sierra Leone, Tanzania and Uganda), two L-MICs (Ghana and Nigeria), two H-MICs (Malaysia and Turkey) and five HICs (Denmark, Italy, Sweden, United Kingdom and United States) (table 2). Most hernias included in this analysis were inguinal; in studies reporting other types of hernias, these represented a minority of patients (femoral, 0.1% to 8%; ventral,3 to 11%).

The log-log regression of emergent to total hernias and per capita expenditure on health care revealed a strong correlation (R^2 0·823, figure 2). A plot of the absolute value of dependent variable (emergent to total hernia ratio) residuals revealed that heteroscedasticity was minimized by using the log-log relationship rather than actual (non-transformed) values or actual-log values (data not shown).

Discussion

Our results suggest that the E/TH represents a potential health indicator for surgical capacity. This proposed indicator is robust in both developed and developing countries as the correlation holds true across world bank income levels. Our experience in Malawi also suggests that the E/TH is easy to obtain even in resource-poor settings.

One advantage of the E/TH is that it is comprised of general surgical procedures. This is in contrast to the C/O ratio which relies on Cesarean sections and total surgical procedures; this may be valid in settings where the same staff and resources are utilized for both types of surgeries such as rural settings in developed countries and district hospitals in developing countries. However, indicators such as E/TH that are specialty-specific are necessary for several reasons. First it allows for better monitoring and evaluation of specialty-specific interventions. In our setting, for example, we have developed a general surgery residency training program for Malawian general practitioners.(36) Assessing surgical capacity before and after this intervention using the C/O ratio would likely not show the same impact as the E/TH ratio. As Malawi and other countries develop, specialization will increase; providers will have a narrower scope of practice and dedicated infrastructure will be created for

specialties (such as maternity hospitals and children's hospitals). Already in Lilongwe, Malawi, there is a separate women's hospital (The Ethel Mutherika Maternity Ward) which is distinct from the main hospital (Kamuzu Central Hospital).

There are other advantages of E/TH over the C/O ratio when comparing countries across income levels. When applied in developing countries, the C/O ratio includes only emergent cases in the numerator, as most (if not all) Cesarean sections are emergent in this environment. In developed countries there is a mix of both elective and emergent Cesarean sections. Therefore the indicator C/O is actually comparing different procedures; perhaps a more accurate method of applying the C/O to both HICs and LMICs would be to use the ratio of emergent Cesarean sections to total cases.

Prior research investigating the utility of hernia repair as a health indicator has been described, however they had several limitations compared to our approach. Petroze *et al.* conducted a study in Rwanda in which they calculated both the C/O ratio and the ratio of hernia repair to total procedures (%Hernia) at 40 different district hospitals.(11) The authors also used the WHO Global Initiative for Emergency and Essential Surgical Care (GIEESC) to assess the capabilities of all 40 district hospitals. The authors then dichotomized the hospitals both by C/O ratio and by %Hernia (above or below median for the 40 hospitals), and found that C/O correlated better than %Hernia with hospital capacity (as determined by WHO GIEESC). However, %Hernia did not utilize emergent versus elective hernia data; the key aspect of our proposed E/TH is its ability capture proxies in general surgery for both emergent and total cases. We assume that the provision of emergency surgery by a given health system is much less affected by overall capacity than is elective surgery (assuming demand for emergency surgery does not exceed total surgical capacity). In other words, when faced with limited resources and forced to chose, most providers preferentially care for the acutely ill and those with immediate life threatening surgical diseases. Thus using a ratio that combines both emergent and elective surgery (similar to the C/O ratio applied in developing countries) has advantages over one that relies more heavily on elective surgery (such as the %Hernia).

Other previously proposed measures of surgical capacity examine staff, infrastructure, and outcome variables. A working group concluded that six factors--the number of surgeons, anesthetists, operating theatres and total cases, as well as same day operative mortality and survival to discharge--might be used as measures of surgical capacity.(37) Though the numbers of personnel and operating theatres are intuitive measures of capacity, the use of mortality rates might be more problematic. Even in developed countries debate continues about comparing mortality rates, as this requires very careful risk adjustment(38). Clearly the volume and complexity of cases also varies significantly from country to country(39).

There are several limitations of our study. First, the E/TH ratio requires further validation as a metric prior to its use. There is no accepted gold standard for surgical capacity; we have chosen to compare E/TH to health care spending as a next best option. Further work might compare E/TH and WHO GIEESC indicators across hospitals within a country (as in Petroze *et al.*), look at temporal changes of the E/TH associated with country-wide changes in capacity (as in Hughes *et al.*), or include data from countries which we did not analyze.

(10, 11) There may also be confounding factors including differing rates of hernias between developing and developed countries, or even regional differences within a country.(40) For some rural settings, emergent or elective hernias may be referred to a larger hospital due to lack of skills or capacity to perform hernia repairs or bowel resections; in such settings our indicator would not be applicable. Out of necessity due to limited data sources, we compared different types of hernias (groin, inguinal or external) based on available data; this approach clearly introduces heterogeneity; future research might compare only one type of hernia to address this bias. Our study is also prone to the effects of publication bias, as we were only able to analyze data from countries with published data; it is possible that data from other countries that is not available in the published literature could influence our findings. Lastly our analysis assumes that the best possible ratio for E/TH is zero, but in reality there will always be some emergent hernias even if every person with a hernia had a repair: the re-operation rate after groin hernia repair is between two and three per cent; perhaps we should adjust our values for E/TH by subtracting two or three per cent from the E/TH prior to comparing to other health indicators.(14)

We conclude that the E/TH ratio represents a possible indicator of surgical capacity for future study and inclusion in health indicators. Validation and implementation of such indicators will provide a useful complement to other currently utilized measures seen in the Millennium Development Goals (MDGs) for the specialties of pediatrics (child mortality), obstetrics and gynecology (maternal health), and internal medicine (HIV/AIDS and malaria). Recently there is significant interest in improving surgical care in developing countries (Alliance for Surgery and Anesthesia Presence and the Bethune Roundtable groups, for example).(41, 42) The time is now to develop surgical capacity indicators such as E/TH. The WHO World Health Statistics should strive to include more surgical metrics and it would be a missed opportunity if the next round of Millennium Development Goals again fail to set direct targets for improving surgical care.

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- Data on hernia repairs are easy to obtain in a developing country
- The ratio of emergent to total hernias correlates to a nation's health care spending
- This correlation was found across all world bank income levels

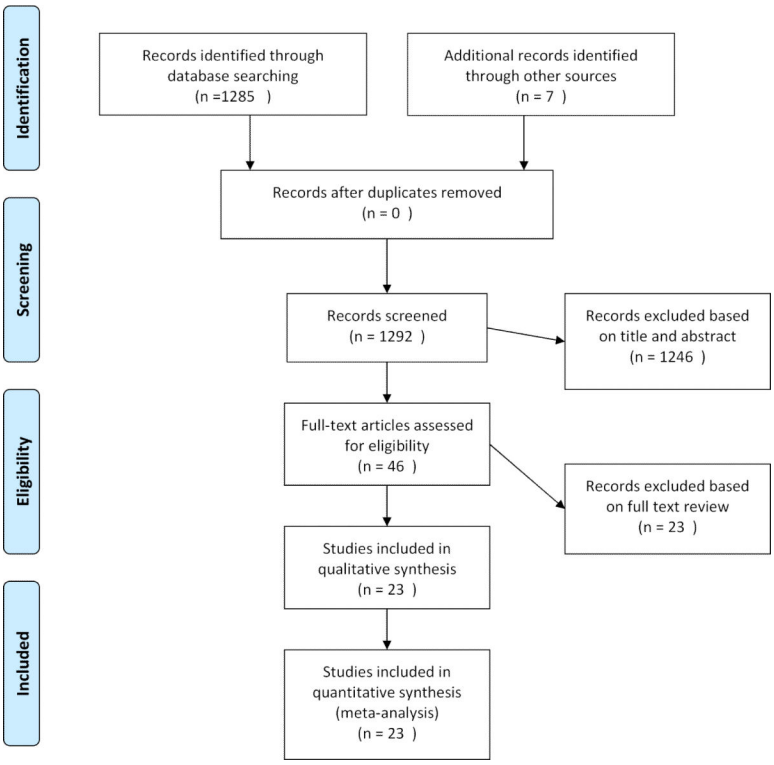

Figure 1.

Prisma flow diagram indicating the number of studies during identification, screening, eligibility, and inclusion steps.

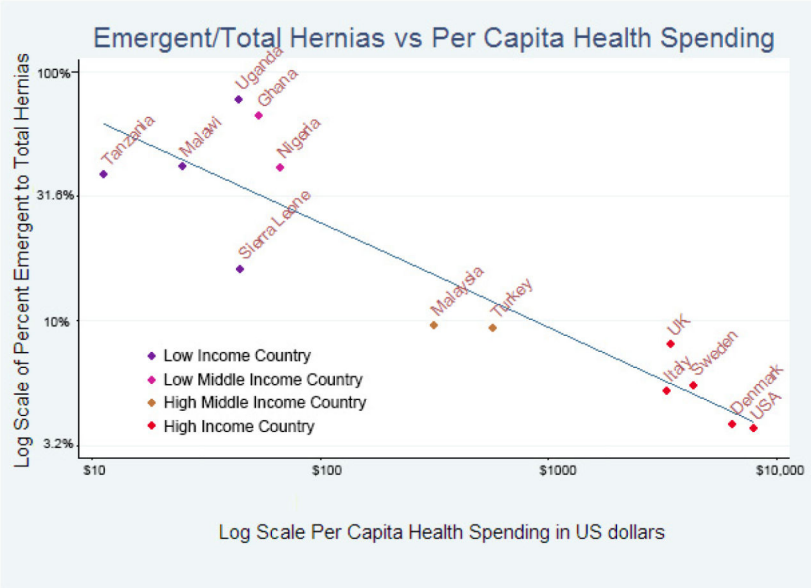

Figure 2.

The log scale of per capita health care spending versus the emergent to total hernia ratio, with specific World Bank country income level indicated.

Table 1

Publications meeting inclusion criteria

Journal	Country	Time Period	Hernia Type	Emergent Cases	Total Cases	Ratio %
Hernia(12)	Denmark	2003-2008	Groin	1829	51233	3·6
The Lancet(13)	Denmark	1998-2000	Groin	1156	26304	4·4
Hernia(14)	Ghana	1998-2007	External	1294	1956	66·2
Hernia(15)	Italy	2000-2009	Inguinal	6653	126913	5·2
Asian Journal of Surgery(16)	Malaysia	2001-2002	Inguinal	9	94	9·6
West African Journal of Medicine(17)	Nigeria	2000-2002	Inguinal	52	227	22·9
The Nigerian Journal of Surgical Research(18)	Nigeria	1987-1998	External	398	870	45·7
World Journal of Surgery(19)	Sierra Leone	1992-1994	External	45	280	16·1
Annals of Surgery(20)	Sweden	1992-2005	Inguinal	5763	98084	5·9
British Journal of Surgery(21)	Sweden	1992-2003	Groin	4859	82452	5·9
Hernia(22)	Sweden	1992-1997	Groin	1101	18170	6·1
Annals of Surgery(23)	Sweden	1998-2009	Groin	7089	143525	4·9
BMC Research Notes(24)	Tanzania	2010-2012	Inguinal	174	452	38·5
Hernia(25)	Turkey	2005-2009	Groin	60	643	9·3
The American Journal of Surgery(26)	Turkey	1996-1999	External	385	3010	12·8
East and Central African Journal of Surgery(27)	Uganda	2000	Inguinal	160	208	76·9
International Journal of Epidemiology(28)	UK	1976-1986	Inguinal	2738	30675	8·9
British Journal of Surgery(29)	UK	1998-1999	Groin	294	5124	5·7
International Journal of Clinical Practice(30)	UK	2000-2001	Groin	37	532	7·0
Hernia(31)	UK	2005-2007	Groin	135	3599	3·8
Journal of the American College of Surgeons(32)	USA	2001-2009	Groin	68	1194	5·7
Hernia(33)	USA	1989-2008	Inguinal	136	4026	3·4
Surgical Endoscopy(34)	USA	1999-2005	Groin	46	1589	2·9

Table 2

Composite values for each country.

Country	Income Level	Emergent Cases	Total Cases	Ratio(%)	Log Ratio(%)	Per capita health expenditures	Log (per capita health expenditures)
Uganda	Low	160	208	76·9	1·89	44	1·64
Ghana	Low Middle	1294	1956	66·2	1·82	54	1·73
Malawi	Low	88	212	41·5	1·62	25	1·40
Nigeria	Low Middle	450	1097	41·0	1·61	67	1·83
Tanzania	Low	174	452	38·5	1·59	27	1·05
Sierra Leone	Low	45	280	16·1	1·21	45	1·65
Malaysia	High Middle	9	94	9·6	0·98	316	2·50
Turkey	High Middle	60	643	9·3	0·97	575	2·76
UK	High	3204	39930	8·0	0·90	3440	3·54
Sweden	High	18812	342231	5·5	0·74	4347	3·64
Italy	High	6653	126913	5·2	0·72	3323	3·52
Denmark	High	2985	77537	3·8	0·59	6452	3·81
USA	High	250	6809	3·7	0·56	7960	3·90