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Characterizing the Global Burden of Surgical Disease: A Method to Estimate Inguinal Hernia Epidemiology in Ghana

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Abstract

Background Surgical conditions represent an immense yet underrecognized source of disease burden globally. Characterizing the burden of surgical disease has been defined as a priority research agenda in global surgery. Little is known about the epidemiology of inguinal hernia, a common easily treatable surgical condition, in resource-poor settings.

Methods Using data from the National Health and Nutrition Examination Survey prospective cohort study of inguinal hernia, we created a method to estimate hernia epidemiology in Ghana. We calculated inguinal hernia incidence and prevalence using Ghanaian demographic data and projected hernia prevalence under three surgical rate and hernia incidence scenarios. Disability adjusted life-years (DALYs) associated with inguinal hernia along with costs for surgical repair were estimated.

Results According to this approach, the prevalence of inguinal hernia in the Ghanaian general population is 3.15 % (range 2.79–3.50 %). Symptomatic hernias number 530,082 (range 469,501–588,980). The annual incidence of symptomatic hernias is 210 (range 186–233) per 100,000 population. At the estimated Ghanaian hernia repair rate of 30 per 100,000, a backlog of 1 million hernias in need of repair develop over 10 years. The cost of repairing all symptomatic hernias in Ghana is estimated at US$53 million, and US$106 million would be required to eliminate hernias over a 10-year period. Nearly 5 million DALYs would be averted with the repair of prevalent cases of symptomatic hernia in Ghana.

Conclusions Data generated by our method indicate the extent to which Ghana lacks the surgical capacity to address its significant inguinal hernia disease burden. This approach provides a simple framework for calculating inguinal hernia epidemiology in resource-poor settings that may be used for advocacy and program planning in multiple country contexts.

Introduction

Surgical conditions represent an immense yet underrecognized source of disease burden globally. Current estimates indicate that 11 % of the world's disability adjusted life-years (DALYs) result from conditions likely to require surgery [1]. In 2009, the Bellagio Essential Surgery Group called for country-level assessment of surgical disease burden as a priority research agenda in global surgery [2]. Although efforts are underway to characterize the epidemiology of certain surgical conditions, infrastructure constraints in resource-poor settings make such studies difficult in practice [3]. Innovative methods to quantify the global burden of surgical disease are needed to guide programmatic intervention and to inform advocacy efforts.

Inguinal hernia is a common surgical condition, with millions of hernias repaired annually worldwide [4]. Mock and colleagues have defined inguinal hernia as a "Priority 1 surgical condition" because it represents a significant global public health burden but can be treated with a simple, cost-effective surgical procedure [5]. In fact, recent estimates suggest that inguinal hernia repair with mosquito

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net mesh is nearly as cost-effective as a vaccine [6]. Elective inguinal hernia repair can prevent rare but serious and costly complications including strangulation, bowel obstruction, and death. It allows patients to regain functional status and engage in productive activity.

Despite high disease prevalence, the current published literature on inguinal hernia epidemiology is limited, even in the United States and western Europe. To date, there has been no household survey of inguinal hernia. Subtlety in clinical diagnosis of inguinal hernia may contribute to our limited epidemiologic knowledge of the disease. Data from World War II cohorts demonstrated the inguinal hernia prevalence was between 6.5 and 8.0 % in American soldiers [7]. A 1996 UK study found a lifetime risk of inguinal hernia repair of 27 % for men and 3 % for women, indicating an immense inguinal hernia disease burden [8]. Elective tension-free repair with mesh is currently the standard of care in wealthy countries for patients with symptomatic inguinal hernia [9, 10]. According to the literature, a watchful waiting strategy may be safely observed for patients with asymptomatic hernia [10].

In sub-Saharan Africa, the epidemiologic and clinical picture of hernia is somewhat different. Although an estimated 7.7 % of adult men in rural southern Ghana had inguinal hernia during the 1970s, the prevalence of this condition was found to be as high as 30 % on the island of Pemba in East Africa in 1969 [11, 12]. Current data on hernia prevalence and incidence in sub-Saharan Africa are lacking. Most cases go untreated in resource-poor settings, resulting in massive, painful hernias that often preclude engaging in work [6, 13]. Recent research indicates that up to two-thirds of inguinal hernias are repaired under emergency conditions in Ghana, resulting in increased costs both to the patient and medical system [14]. Whereas hernia complications are rarely deadly in wealthy countries, mortality from hernia strangulation even with access to surgical care is 40 % in Niger [15].

Approximately 800,000 inguinal hernia repairs were performed in the United States in 2003, making the surgical repair rate of inguinal hernia 275 per 100,000 population in the country [16]. Annual inguinal hernia repair rates are lower in the United Kingdom and Sweden, at 100 and 180 per 100,000 population, respectively [17]. In 1984, Nordberg suggested the yearly minimum need for elective and emergent inguinal hernia repair in East Africa to be 205 per 100,000 [18]. Although this estimate has served as a benchmark in the global surgery literature, the ideal inguinal hernia repair rate under current practice guidelines has yet to be determined [19]. For comparison, the average district hospital in sub-Saharan Africa performs just 30 inguinal hernia repairs per 100,000 population per year [19].

To better characterize the hernia disease burden in resource-poor settings, we suggest a method for estimating inguinal hernia epidemiology in Ghana. The approach utilizes prospective cohort data from the United States to calculate inguinal hernia prevalence and incidence along with costs associated with repair. This method may be applied in other country contexts using easily accessible local demographic data. Hopefully, data gleaned from such calculations will be used for projections of unmet surgical need and, in turn, global surgery advocacy.

Materials and methods

In 2007, Ruhl and Everhart studied risk factors for inguinal hernia in adults using data from the prospective cohort of the National Health and Nutrition Examination Survey (NHANES) [20]. They found that the average cumulative incidence of inguinal hernia in the NHANES cohort was 6.3 % over 20 years. As predicted, the cumulative incidence of hernia was higher in men (13.9 %) than in women (2.1 %) [20]. Based on our review of the literature, this analysis provides the most comprehensive, reliable data currently available on hernia epidemiology in the United States. Therefore, we decided to use this data in our epidemiologic approach. To aid our analysis, we obtained unpublished data on the standard error of NHANES inguinal hernia incidence figures. Currently, there is no evidence to suggest that rates of inguinal hernia are lower in sub-Saharan Africa than in the United States, making the application of U.S. statistics to the Ghanaian context appropriate in this circumstance of limited data.

First, we calculated a yearly cumulative incidence as 0.315 %, or 315 incident cases of inguinal hernia per 100,000 population (6.3 % divided by 20 years). Using the equation $P = I \times D$—a simplified relation between prevalence (P) and incidence (I) for situations where $P < 10$ %—we then calculated the prevalence of inguinal hernia in Ghana today. To do this, we set the duration of hernia (D) at 10 years, which is likely an underestimate, as research suggests some men in neighboring Nigeria present for surgical care up to 25 years after hernia onset [21]. We conducted a similar analysis for inguinal hernia prevalence in men, calculating the yearly cumulative incidence of hernia as 0.695 % (13.9 % divided by 20 years) in men. This calculation was done to allow comparison with data from the 1978 study on prevalence of inguinal hernia in Ghanaian men. We used the 2012 Ghanaian population of 25,241,998 for further calculations [22].

Next, we conducted a sensitivity analysis of our point estimate of hernia cumulative incidence. Using the standard errors of hernia incidence in the NHANES cohort, we calculated the 95 % confidence interval (CI) for the NHANES 20 year incidence of inguinal hernia as

5.58–6.97 %. This technique provided us with a range of inguinal hernia incidence figures, which we present following our point estimates of incidence and prevalence. We have applied the range estimates to subsequent description of "Best case" and "Worst case" scenarios for inguinal hernia prevalence in Ghana in the context of various surgical repair rates.

According to the literature, about one-third of patients with inguinal hernia in the United States are asymptomatic [17]. Therefore, we assumed that only two-thirds of incident hernias in Ghana would require repair in the model by the watchful waiting standard. This makes the annual incidence of symptomatic inguinal hernia requiring surgical intervention 210 per 100,000 population. The following equation was used to calculate the number of inguinal hernias in Ghana in need of repair, including prevalent ($0.021p$) and incident cases ($0.0021px$) over the 10-year time period:

$$y = 0.021p + 0.0021px$$

where y is the number of inguinal hernias, x is the year, and p is the population

Next, we constructed a 10-year open cohort of Ghanaians with inguinal hernia, ultimately creating a graphic representation of disease incidence and prevalence (see "Results"). The current surgical capacity for inguinal hernia in Ghana was estimated to be 30 per 100,000 [19]. This average surgical rate was used to facilitate application of our epidemiologic approach to other countries in sub-Saharan Africa. In addition, we calculated inguinal hernia prevalence under several surgical rate scenarios to better characterize surgical capacity needs for inguinal hernia in Ghana according to the following equations:

Ghana repair rate :

$$y = 0.021p + 0.0021px - 0.0003px$$

US repair rate :

$$y = 0.021p + 0.0021px - 0.00275px$$

Hernia elimination repair rate :

$$y = 0.021p + 0.0021px - 0.00420px$$

where y is the number of inguinal hernias, x is the year, and p is the population

Finally, to determine the financial need for hernia surgical capacity building in Ghana, we used cost estimates from work done by Operation Hernia, a UK nonprofit organization with extensive experience in inguinal hernia repair in resource-poor settings [6]. We used the Operation Hernia cost of US$100 per tension-free inguinal hernia repair with mosquito net mesh and spinal anesthesia for our cost calculations [6]. In addition, we used Operation Hernia's figure of 9.3 DALYs averted per inguinal hernia repair to obtain a sense of the scope of disease burden estimated by our epidemiologic approach [6].

Results

According to this method, the prevalence of inguinal hernia in the Ghanaian general population is 3.15 % (range 2.79–3.50 %), meaning that today nearly 800,000 Ghanaians have inguinal hernia. About two-thirds of these patients are likely to be symptomatic. There are thus 530,082 hernias (range 469,501–588,980 hernias) in Ghana today that need repair. Each year, there are 210 (range 186–233) per 100,000 new cases of symptomatic hernia. This amounts to 53,008 (range 46,950–58,898) incident inguinal hernias annually in Ghana. The sex subanalysis revealed an inguinal hernia prevalence of 7.0 % in men.

Figure 1 illustrates the prevalent and incident cases of inguinal hernia projected over 10 years. At the current estimated hernia repair rate in Ghana of 30 per 100,000, there will be a backlog of 1 million hernias for repair in 10 years. As shown in Fig. 1, Ghana's current repair rate will have minimal impact on the hernia disease burden in the country over the next 10 years.

Figure 2 demonstrates the change in inguinal hernia prevalence in Ghana associated with three surgical rate scenarios: Ghana's current surgical rate, the U.S. repair rate, and an elimination repair rate. The latter figure has been included to emphasize that even at current U.S. repair rates, all cases of inguinal hernia needing surgical repair will not be addressed in 10 years. A surgical rate of 420 per 100,000 would be required to eliminate hernia in 10 years according to our calculations.

We suggest three possible scenarios of inguinal hernia epidemiology in Ghana in Table 1. The standard scenario has been previously described. The best and worst case scenarios are based on the upper and lower confidence intervals of incidence from the NHANES data. In the best

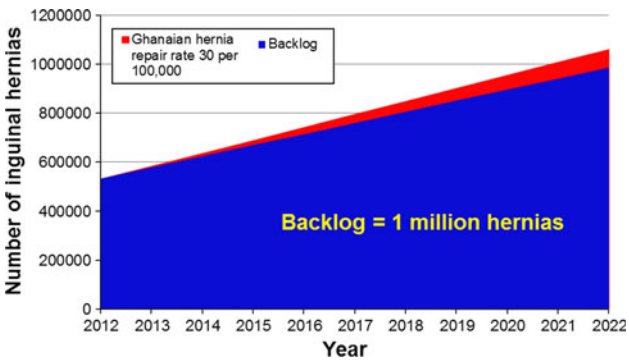

Fig. 1 Backlog of inguinal hernia cases at Ghana's current surgical repair rate over a 10-year period

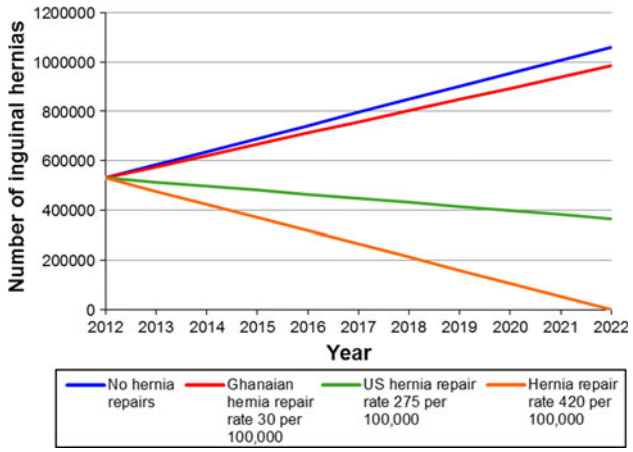

Fig. 2 Prevalence of inguinal hernia in Ghana under three surgical rate scenarios

case scenario, we assume the lower limit of prevalence (3.15 %) with the U.S. repair rate. In this case, the hernia yearly incidence is 186 per 100,000 population, and the 10-year backlog drops to <250,000. In the worst case scenario, the hernia incidence reaches 233 per 100,000 population but is addressed with the current Ghana repair rate, yielding a 10-year backlog of 1.1 million hernias. DALYs associated with the 10-year backlog are also presented in Table 1.

We estimate the cost of repairing all symptomatic inguinal hernias today in Ghana with mosquito net mesh to be US$53 million, whereas US$103 million would be required to eliminate hernia over the next 10 years. A budget of US$5.3 million per year would be needed to repair incident inguinal hernias in Ghana. Using Operation Hernia estimates, nearly 5 million DALYs would be averted with the repair of prevalent cases of symptomatic hernia in Ghana today [6]. Addressing annual incident cases of hernia in Ghana would avert 493,000 DALYs, or 20 DALYs per 1,000 population per year.

Discussion

This epidemiologic approach has some important implications. First, our inguinal hernia DALY calculations indicate that the current global burden of surgical disease is grossly underestimated. According to the model, 5 million DALYs are attributable to inguinal hernia in Ghana. This figure represents one-fifth of Africa's total surgical DALYs as estimated by Debas and colleagues [1]. According to our data, DALYs associated with inguinal hernia (20 per 1,000 population per year) are comparable to similar World Health Organization disease burden figures for malaria (27 DALYs per 1,000 population per year) and diarrheal disease (20 DALYs per 1,000 population per year) in Ghana [23]. In addition, our approach suggests that Ghana's population disease burden of inguinal hernia is nearly double that of tuberculosis, further indicating the scope of this problem and its public health implications [23].

Data from this method substantiate early estimates of surgical need for inguinal hernia repair in sub-Saharan Africa. As previously mentioned, Nordberg's recommended surgical rate for East Africa of 205 per 100,000 population has been cited in the literature as an ideal goal [18, 19]. With our approach, the incidence of symptomatic hernias in Ghana was similar to Nordberg's figure at 210 per 100,000. However, the model used prospective cohort data of hernia incidence, which is likely more reliable for determining ideal capacity than the international surgical rates used by Nordberg. Our subanalysis found an inguinal hernia prevalence of 7.0 % in men, which compares favorably to previous estimates of hernia epidemiology in Ghana from the 1970s [11]. This consistency in our prevalence and incidence figures further argues for the appropriateness of our application of the NHANES hernia data to the Ghanaian context.

Our sensitivity analysis indicates the extent to which surgical need may vary with estimated incidence. In addition, we demonstrate the effect of various surgical repair rates on our projection of the 10-year case backlog. Although our range of epidemiologic figures is not particularly wide, further precision in the estimation of annual hernia incidence is needed to define more clearly an appropriate surgical rate.

The main asset of our approach is its simplicity. The technique described could be easily applied to estimate inguinal hernia burden in other countries with simple demographic data. It might even be useful for characterizing the epidemiology of other chronic diseases with minimal mortality. Of course condition-related mortality

Table 1 Three scenarios of inguinal hernia epidemiology in Ghana

Scenario	Inguinal hernia prevalence (%)	Symptomatic inguinal hernia incidence[a]	Surgical repair rate[a]	10-Year case backlog	DALYs associated with backlog (in millions)	Hernia elimination repair rate[a]
Standard	3.15	210	30	984,438	9.2	420
Best case	2.79	186	275	244,847	2.3	372
Worst case	3.50	233	30	1,100,551	10.3	466

[a] Per year per 100,000 population

would need to be included in more complex disease models as has been done in a similar model for diabetes epidemiology in the United States [24]. Our approach puts hard numbers on the disease burden of inguinal hernia in Ghana, indicating a clear unmet need for surgical repair of hernia in the country.

Addressing inguinal hernia in Ghana will be costly. Our figures indicate that an estimated US$53 million would be required to repair prevalent cases of symptomatic inguinal hernia in Ghana today, and US$5.3 million would be needed to address new cases each year. Although this is a sizable amount of money, indirect benefits, including health systems strengthening and surgical capacity building, would likely accompany a rollout of inguinal hernia repair in Ghana. In addition, the economic burden from lost productivity of male heads of households would be mitigated with increased access to inguinal hernia repair in Ghana. In one Ghanaian study, more than 63 % of patients presenting for elective repair reported limitations in occupational activity, indicating the extent of inguinal hernia morbidity in this population [6]. For cost comparison, US$175 million in Global Fund grants have been dedicated to human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) care over the past several years in Ghana, where HIV prevalence is 1.9 % [25, 26]. Although this money has financed prevention efforts along with the treatment of 40,000 people living with HIV/AIDS, the repair of more than 1 million inguinal hernias could be accomplished with a smaller budget over a 10-year period in Ghana.

Our approach has some limitations. The incidence of inguinal hernia generally increases with age, so a method utilizing age-standardized hernia incidence would be more accurate. Such demographic data are not readily available for many countries in sub-Saharan Africa, making age adjustment not feasible in all contexts. Hernia-specific mortality was also not included in the calculations, given the lack of data. Although this figure is likely low, it could have biased our data toward a higher hernia prevalence. In addition, we assumed a steady state of entrance into and exit from the cohort, although this may have underestimated the cohort population as Ghana's population growth rate is nearly 2 % per year [22]. Finally, following generally accepted inguinal hernia management principles, we included only symptomatic cases in calculations of surgical need. Whether watchful waiting is a safe option for the management of asymptomatic hernias in resource-poor settings has never been studied.

Although prevalence and incidence figures are in line with previously published estimates, our approach has not been validated by current real-world data. A study of inguinal hernia epidemiology is planned for Ghana, and we look forward to validating the method described with the data.

Conclusions

A surprisingly small number of epidemiologic studies of inguinal hernia have been carried out in wealthy countries, likely because surgical management standards are clearly established in this context. Characterizing the burden of surgical disease is important for advocacy, resource allocation, and program planning. In a situation of strict resource limitation, however, it may not be ethical to study inguinal hernia epidemiology in multiple contexts where surgical repair of all cases is not feasible. The approach presented represents a free and easy method to formulate preliminary estimates of inguinal hernia epidemiology in resource-poor settings.

Perhaps what this method best demonstrates is the situation we see echoed repeatedly throughout the global surgery literature: Current health systems in resource-poor settings lack the capacity to address the local surgical disease burden. Fortunately, innovative and cost-effective approaches to improve quality of care and increase capacity for treating surgical conditions in resource-poor settings do exist, including mosquito net mesh inguinal hernia repair and comprehensive, effective task-shifting initiatives such as Mozambique's *técnicos de cirurgía* program [27, 28]. We have enough information today to say definitively that the need for surgical care in resource-poor settings is immense. The time for transition from information gathering to advocacy and action has come for global surgery.

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Conflict of interest None.

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