Cost-effectiveness of Groin Hernia Surgery in the Western Region of Ghana

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Objective: To calculate the cost-effectiveness of tension-free inguinal hernia repair with mosquito net mesh in the Western Region of Ghana.

Design: Prospective study.

Setting: Four district hospitals in the Western Region of Ghana.

Patients: A total of 113 referred or presenting patients from rural areas with inguinal hernias of various sizes.

Intervention: Lichtenstein method of tension-free repair using mosquito net mesh by European and African surgeons.

Main Outcome Measure: Disability-adjusted life-years (DALYs) averted with counterfactual definitions based on precedent and expert opinion.

Results: All operations were performed as day cases, with 81 of the patients (71.7%) under local anesthesia and few complications. An average of 9.3 (95% confidence interval [CI], 8.0-10.7) DALYs were averted per person, with a total of 1052 averted in the study. Average cost per patient was $120.02 (95% CI, $117.66-$122.39) from a provider perspective and $102.88 ($88.47-$117.29) from a patient perspective. Cost-effectiveness was $12.88 per DALY averted (95% CI, $10.98-$14.78), which is well below the Ghanaian per capita gross national income ($590). Results were robust to sensitivity analysis and may be refined as further work is done on the burden of disease due to hernias in Africa.

Conclusions: Inguinal hernia repair was cost-effective in the Western Region of Ghana through international collaboration. Research in other settings should test the generalizability of results.

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Both disability-adjusted life-years (DALYs) and quality-adjusted life-years measure health outcomes according to preference for health states and timing of death to inform public health decisions. Quality-adjusted life-years measure increases in life expectancy and improvements in health states; DALYs measure the reductions in premature death and disability and are most commonly used in low- and middle-income country (LMIC) settings.

See Invited Critique at end of article

Initial estimates indicate that surgery can address 7% of DALYs that occur in Africa, and this burden is probably increasing rapidly. The economic impact of these conditions is significant because they often disable or kill people in the prime of their life; however, surgery in LMICs has been a neglected public health need, with the perception of costs, training, and resource requirements exceeding what is feasible in resource-poor environments. In reality, only basic skills and equipment are needed to sustain essential surgical services, making them feasible at first-referral–level health facilities. Surgery is therefore gaining recognition in international health agendas. Inguinal hernia repair is one of the most commonly performed operations in Africa. It is estimated that 175 people per 100 000 need hernia repair each year, with prevalence estimates as high as 1400 per 100 000 in Carpenter, Northern Region of Ghana (A.N.K., unpublished data, 2008). However, only a small percentage are actually repaired, often resulting in long-standing inguinoscrotal hernias (Figure 1). Waiting is associated with a higher incidence of morbidity and mortality, requiring expensive emergency care for many patients. Although significant progress has been made to increase uptake of surgery in Accra, strangulated inguinal hernia is still a common problem in rural areas because simple surgical services are unavailable or unaffordable. There is an urgent need to make hernia repair more available and accessible to the geographic and social groups that need it.

The only evidence on the cost-effectiveness of inguinal hernia repair in
LMICs is based on expert opinion, although it is listed as an essential service provided by district hospitals in *Disease Control Priorities in Developing Countries*, second edition. Our study meets the calls for cost-effectiveness evidence on surgical interventions in LMICs by assessing outpatient inguinal hernia repair by the Lichtenstein method using mosquito net mesh relative to no treatment at 4 rural hospitals in western Ghana.

**METHODS**

Operation Hernia is a UK-based nongovernmental organization that links Takoradi Regional Hospital in Ghana with Derriford Hospital in Plymouth, England, and other international surgical teams. It has been in operation since 2005, adding a hernia treatment center in Takoradi, where European surgeons operate up to 10 weeks per year, repairing about 50 hernia cases per week. In November 2007, a team from the United Kingdom/Netherlands worked with a local team to repair hernias at 4 regional hospitals for 3 days, recruiting patients through advertisements and referrals. Medical details about the mission and intervention are described in another article.

Data relating to patient demographics, clinical presentation, and patient-perspective costs were obtained before surgery. Each hernia was assessed by the operating surgeon, and inguinal hernias were classified preoperatively by Kingsnorth’s method based on the size of the hernia (H1-H4) and obesity of the patient (F1-F4) (Table 1). Lichtenstein tension-free mesh repair was performed for all cases of inguinal hernia, using sterilized 100% polyester mosquito net mesh (Scotmas Group, Kelso, Scotland) and nylon sutures. All procedures were performed with the patient under local anesthesia except in young children or where the hernia was large and irreducible. Patients were discharged on the same day, and follow-up for wound checks was organized with the local hospital.

Health outcomes were calculated according to World Health Organization burden of disease equations. A framework for approximating utility weights, probabilities of survival without treatment, and incremental calculations based on McCord and Chowdhury was used, informed by the opinions of one of us (A.N.K.) (Table 1). The spreadsheet to calculate DALYs is available from the authors.

The DALYs were calculated according to a discount rate of 3% with no age weighting, to be consistent with analyses in *Disease Control Priorities in Developing Countries*. Average life span data for each age were taken from sex-specific World Health Organization Model Life Tables for Ghana. If a patient had more than 1 hernia, the life expectancies and disability weights associated with the more severe-grade hernia were used in the reference case. Underlying DALY assumptions were tested in sensitivity analysis, along with scenarios that considered the effect on health according to total inguinal hernias repaired and the effect if treatment were provided within 1 year of onset.

Costs were calculated from a provider perspective, consisting of variable costs (associated with utilization and volume driven) and fixed costs (independent of patient volume). A sensitivity analysis from the patient perspective was performed, replacing variable costs to the provider with patient out-of-pocket costs. Inclusion of the “shadow price” of European surgeon salaries and exclusion of patients with costs 1.96 SDs from average were also tested in 2 separate sensitivity analyses. Cost components from previous years were converted to US dollars by means of year-average exchange rates and inflated to 2008 by using the US gross domestic product deflator.

Resource use for variable costs was recorded prospectively. Unit costs were drawn from the International Drug Price Indicator Guide, Ghana Pharmaceutical Pricing Study, the World Health Organization Choosing Interventions That Are Cost-effective (WHO-CHOICE) project, an unpublished US Agency for International Development report, and catalog prices from local and international medical suppliers. Out-of-pocket costs were collected in a patient survey after treatment, which included both direct and indirect costs of treatment seeking.

Fixed costs were annualized according to factors corresponding with the life span of the component, based on values from WHO-CHOICE, and prorated to a 5-day time frame. Building improvements included the construction of the hernia treatment center at Takoradi and refurbishments to the remaining 3 hospitals. Furniture and equipment costs were based on standard requirements for a facility found in the region by the Operation Hernia team. Utilities consisted of water and electricity, accounting for a backup diesel generator. Figures from Gosselin and colleagues were used to represent costs for land purchase, hospital construction, and building and equipment maintenance. A media campaign of 120 radio minutes was included.

Incremental cost-effectiveness ratios were calculated by comparing hernia repair with a hypothetical no-treatment scenario. The impact of variation in patient-level costs and health outcomes was represented by using probabilistic sensitivity analysis according to standard Monte Carlo simulation (10 000 iterations). Cost-effectiveness acceptability curves were generated to show the robustness of policy recommendations according to variations in valuation of healthy life-years. Several sensitivity analyses were conducted, evaluating variations in DALY assumptions, the patient perspective, excluding cost out-

![Figure 1. Large inguinal hernia. These hernias can be several centimeters in diameter and debilitating, affecting a person’s ability to maintain a livelihood and function normally in everyday life.](http://archsurg.jamanetwork.com/)


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Patients were also graded according to obesity, defined in terms of subscapular skin fold thickness: F1, less than 15 mm (39 patients); F2, 15 to 25 mm (68 patients); F3, 26 to 35 mm (6 patients); and F4, greater than 35 mm (0 patients).

Sixteen of the 113 patients (14.2%) reported vomiting, (13.7%) were irreducible, and 1 (0.8%) was obstructed.

Eleven hernias (9.4%) were recurrent. From data collected on 124 hernias, 106 (85.5%) were reducible, 17 (13.7%) were irreducible, and 1 (0.8%) was obstructed. Sixteen of the 113 patients (14.2%) reported vomiting, with 85 (75.2%) reporting pain. The median time that patients had lived with their hernia was 3 years, with the longest duration being 42 years. Seventy-one of 112 patients (63.4%) reported limitations in activities such as recreation, occupation, or procreation, and 39 (34.8%) reported limitations in 2 or more areas. Ten of the total 113 patients (8.8%) reported having a limitation in daily living such as bathing, cooking, walking, or housework.

Mosquito net mesh was used to repair 107 inguinal hernias (86.3%), including 22 bilateral inguinal hernias (17.7%), with the rest being corrected by herniotomy (15 cases [12.1%]), by reinforcement of previous mesh (1 case [0.8%]), or without mesh (1 case [0.8%]). Local anesthesia was used for 81 of the 113 patients (71.7%), specifically lidocaine hydrochloride, 1%, or bupivacaine hydrochloride, 0.5% or 0.25%, and epinephrine, with general anesthesia being used in the remaining 32 (28.3%). The average duration of each operation was 50 minutes (shortest, 20 minutes; longest, 2 hours). Seventy-one patients (62.8%) received intraoperative medication, most commonly meperidine hydrochloride or a combination of other analgesics and nonsteroidal anti-inflammatory drugs.

We calculated DALYs with a discount rate \((r)\) of 3 and an age-weighting modulating factor \((K)\) of 0 in the reference case, with an average of 9.3 (95% confidence interval [CI], 8.0-10.7) DALYs averted per person and 1052 (902-1204) total DALYs averted in the study (Table 3).
Of these, 39% were attributable to years of life lived with disability and 61% due to years of life lost. Varying discounting to 0% and 6% had a significant effect on results, ranging from 714 to 1726 DALYs averted. Introducing age weighting increased the DALYs averted by 10%.

Years of life lived with disability incurred before surgery were not included in calculations, leading to a conservative estimate of the impact of an established program. A program that addresses hernias during the same year of onset would avert 25 (2.4%) more DALYs because of fewer years lived with disability. In addition, DALYs were calculated only for the most severe hernia in the reference case. If DALYs are calculated for each inguinal hernia that was repaired (both hernias when bilateral), 43 (4.1%) more are averted relative to the baseline.

Treatment-seeking factors and out-of-pocket costs are presented in Table 4. Institutional financing most commonly came from insurance (40 of 113 patients [35.4%]). Of 112 patients who responded, 41 (36.6%) had to resort to coping mechanisms, and 24 of 110 patients (21.8%) reported that services were forgone because of cost. Sixty-one patients spent an average of $5.83 on transportation ($3.15 sample average), and 3 patients spent an average of $0.81 on food ($0.02 sample average). No patient with an inguinal hernia stayed in the hospital overnight. Patients reported direct out-of-pocket costs to be $72.01 on average.

The average variable cost from the provider perspective was $111.02 per patient (Table 5). These costs were almost exclusively intraoperative and personnel because only small amounts of painkillers and antibiotics were required after surgery. Disposable items accounted for the bulk of intraoperative costs. Fixed costs amounted to $1017.12 ($9.00 per patient) (Table 6). These costs were relatively evenly distributed across categories.

Cost-effectiveness was calculated from provider and patient perspectives (Table 7). From a patient perspective, each patient cost an average of $102.88 (95% CI, $88.47-$117.29) and averted an average of 9.32 (8.0-10.7) DALYs. From a provider perspective, each patient cost an average of $120.02 (95% CI, $117.66-$122.39), leading to an incremental cost-effectiveness ratio of $12.88 per DALY averted ($10.98-$14.78), which compares favorably with a ceiling ratio of $590, the per-capita gross national income of Ghana. The acceptability curve shows that this result is robust to fluctuations in the ceiling ratio, with cost-effectiveness being 95% certain above a valuation of life of $14.66 per DALY averted (Figure 2). Results remain cost-effective even when only 2% of DALYs are averted at baseline parameterizations, or only one-fifth of a DALY is averted per patient. Results were robust to all sensitivity analyses except for the cohort of 7 patients older than 58 years with H1 hernias (Table 7).
This study demonstrated that mosquito net–based tension-free repair of inguinal hernia was cost-effective relative to no treatment at a rural district hospital in Ghana. Results were robust to sensitivity analysis, remaining cost-effective even if 45.81 times fewer DALYs are averted relative to reference case conditions. Qualified surgeons performed operations at a high level of quality and efficiency. Local anesthetic was used, in keeping with evidence and recommendations, eliminating the need for hospital stays. Use of mosquito net mesh eliminated the higher cost of manufactured varieties. The number of hospital stays. Use of mosquito net mesh eliminated the expected, such as the use of capacities to address other types of hernias and life-threatening conditions. Furthermore, 62 patients lost time from work because of their hernias (average, 98 days), and 4 caregivers lost an average of 2.25 days, totaling $42,641.90 in lost wages not accounted for in our cost-effectiveness calculations. The program provided a unique training opportunity for both the European and African practitioners and has stimulated participation among a growing number of surgical teams from other countries. Several articles document levels of interest and incentives surgeons and trainees recognize in international work through programs such as Operation Smile and medical school residency programs.

Limitations of DALYs are described elsewhere and empirical research to support the DALY weights in our calculations is an area for further research. Our estimates are based on methodologic precedent from other studies in the absence of evidence. However, a “watch and wait” approach to repairing large hernias is not recommended, and our results remain cost-effective within limits for health outcomes that extend beyond what is medically plausible.

There is little evidence to predict the outcomes of untreated hernias, which often follow the pattern of irreducibility, incarceration, and strangulation. The literature on strangulation risks focuses on newly diagnosed hernias, usually classified as H1 or H2, although it is recognized that risks may increase in patients with long histories. One study found that 30% of hernias became irreducible at 10 years, and another found that hernias lasting less than 60 months had a 8.6% chance of becoming irreducible. Historical accounts of larger hernias among soldiers serving in the British Army before surgical techniques existed describe them as “by far the greatest wastage in the army.” Whether this wastage was due to death is not mentioned, but these men had access to trusses to reduce and control the hernia, a device unavailable to most African patients. Unsupported hernias are not reduced during daily activities and heavy work, leaving them at great risk of severe outcomes.

Few complications arose after the mission, and all were treated conservatively by a registered nurse without hospitalization. At 6 weeks after surgery, 4.4% of patients returned with hematomas and 1.7% with wound infections, which were managed successfully with antibiotics. These findings were comparable to published evi-
dence. In Scotland, 7% of patients developed wound hematomas within 3 months after surgery, and 5% to 8% developed wound infections despite antibiotic prophylaxis. The cost of managing complications is not included in this analysis but is expected to be negligible because of their infrequency and the fraction of nurse time required. No cases of recurrence or mesh rejection were reported in our study after 6 months.

Evidence showing the return on alternative investments is considered important for clinical and health policy decisions, both in the World Health Organization and at the country level in Africa. Ghanaian health policy makers specifically consider cost-effectiveness a top criterion for choosing between health care programs. Previous evidence in resource-constrained settings has shown favorable cost-effectiveness for district hospitals, with surgical interventions accounting for as many as 60% of the DALYs averted. The only evidence that currently exists on the cost-effectiveness of hernia repair is $108 per year of life saved, on the basis of expert opinion. Although current health system development in Ghana is focused on the Millennium Development Goals, cost-effective interventions without supporting evidence at the time recommendations were made, such as hernia repair, should not be overlooked by the health system.

Improving accessibility of hernia repair should be a priority in international public health, both at the structural level and at the point of care, with particular attention paid to financing strategies. Out-of-pocket costs are the most significant barriers to elective surgery uptake in rural Ghana. National health insurance was introduced in 2001 to protect people in both the formal and informal sectors, and all residents are required to subscribe or use an alternative source. Hernia repair is an excellent candidate for this scheme, meeting the criteria defined by Musgrove for public financing: a public good with constraints to patient demand, a cost-effective intervention with preferential benefit to the poor, and a form of protection against catastrophic costs where private insurance systems are inadequate. More detail on the case for prioritizing hernia repair in African health systems is presented in an accompanying article.

Strategies to improve accessibility are particularly needed in rural areas. In response, Ghana has earmarked $5 million for incentives for health workers who choose to work in underserved areas of the country. Several countries in Africa have created alternative cadres of health workers to increase the availability of surgery, and evidence exists that quality of care outcomes can compare with those of physicians in some circumstances. Given its lower cost, this strategy has been argued to be cost-effective, although proper safeguards are needed to ensure quality standards, and nonphysicians should be used only for less complicated procedures.

Projections of future trends in the cost-effectiveness of hernia repair in Ghana are mixed. Cost-effectiveness of the program can be expected to improve as efficiencies are developed through program expansion. However, cost-effectiveness would be expected to worsen with the spread of human immunodeficiency virus (HIV) if life spans decrease and the number of DALYs averted by each surgery is reduced. Prevalence of HIV in Ghana has increased from 2.4% to 3.6% between 1994 and 2003, and evidence indicates that it is higher in patients undergoing surgery in Africa. On the other hand, improving surgical capacity will be an important part of addressing HIV-related complications such as abscesses, fistulas, and Kaposi sarcoma as the epidemic spreads.

In conclusion, Africa has the highest ratio of DALYs due to surgical conditions per 1000 people of any global region. Evidence from our study indicates that tension-free hernia repair can be cost-effective through international partnerships in a rural district hospital for all patients except those older than 58 years with H1 hernias. The health gains from this type of program can be significant, both in terms of disability and mortality averted, at costs that are affordable to patients and health systems. Larger-scale evaluation of the cost-effectiveness of inguinal hernia repair is warranted to inform recommendations that will scale up access to surgical services in Ghana and similar countries.

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REFERENCES


Surgeon, Do You Know Where Your DALYs Are?

(Can You Fix a Hernia With a Mosquito Net?)

This excellent article introduces surgeons to the concept of DALYs—a metric that, in simple terms, quantifies the gap between current health status and an ideal health situation in which the entire population lives to an advanced age, free of disease and disability. The DALYs measure the outcome of an intervention in terms of the amount of reduction of premature death or disability. While the bulk of the world’s public health care resources have been appropriately focused on the devastating infectious disease burdens of AIDS, malaria, and tuberculosis, the burden and distribution of surgical disease remain largely unknown and neglected. The authors demonstrate the importance of assessing surgical disease in the language of our public health policy makers. Until we merge our languages, we will not be effective advocates of eradicating surgical disease from a public health perspective and will not influence the resource allocation decisions.

It has often been assumed, primarily by nonsurgeon evaluators, that the costs of providing surgical services are prohibitive. However, the authors indicate that, especially where labor is inexpensive, only basic skills and equipment are needed to sustain essential surgical services, such as cesarean section and hernia repair.

Inguinal hernia repair, for example, is a commonly performed operation. If death from strangulated hernia is prevented in a young person in the prime of his or her life, then a significant number of disability-free years are added to that person’s life.

In this article, the authors not only assess the costs and outcomes of hernia repair in terms of DALYs averted but also describe a fabulously clever, inexpensive, and context-appropriate way to treat this specific surgical disease: using locally available mosquito netting and local/regional anesthesia. As we in the United States begin the conversation about the cost-effectiveness of interventions, DALY-type analyses will be necessary to inform our decision making.

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