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Cost-Effectiveness of Inguinal Hernia Surgery in Northwestern Ecuador

Samuel D. Shillcutt · David L. Sanders · M. Teresa Butrón-Vila · Andrew N. Kingsnorth

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Abstract

Background Cost-effectiveness of tension-free inguinal hernia repair at a private 20-bed rural hospital in Esmeraldas Province, Ecuador, was calculated relative to no treatment.

Methods Lichtenstein repair using mosquito net or polypropylene commercial mesh was provided to patients with inguinal hernia by surgeons from Europe and North America. Prospective data were collected from provider, patient, and societal perspectives, with component costs collected on site and from local supply companies or published literature. Patient outcomes were forecasted using disability adjusted life years (DALYs) averted. Uncertainty in patient-level data was evaluated with Monte–Carlo simulation.

Results: Surgery was provided to 102 patients with inguinal hernias of various sizes. Local anesthesia was used for 80 % of operations during the first mission, and spinal anesthesia was used for 89 % in the second mission. Few complications were observed. An average 6.39 DALYs (3,0) were averted per patient (95 % confidence interval: 6.22–6.84). The average cost per patient was US$499.33 (95 % CI: US$490.19–$526.03) from a provider perspective, US$118.79 (95 % CI: US$110.28–$143.72) from a patient perspective, and US$615.46 (95 % CI: US$603.39–$650.40) from a societal perspective. Mean cost-effectiveness from a provider perspective was US$78.18/DALY averted (95 % CI: US$75.86–$85.78) according to DALYs (3,0) averted using the West Life Table level 26, well below the Ecuadorian per-capita Gross National Income (US$3,850). Results were robust to all sensitivity analyses.

Conclusions Inguinal hernia repair was cost-effective in western Ecuador through international collaboration.

S. D. Shillcutt (✉)
Department of International Health, Johns Hopkins Bloomberg School of Public Health, 615 N Wolfe St, Baltimore, Maryland 21205, USA
e-mail: sshillcu@gmail.com

D. L. Sanders
Department of Upper Gastrointestinal Surgery, Royal Cornwall Hospital, Truro TR1 3LJ, UK

M. Teresa Butrón-Vila
Department of General and Digestive Surgery, Hospital Universitario 12 de Octubre, Madrid, Spain

A. N. Kingsnorth
Department of Upper Gastrointestinal Surgery, Derriford Hospital, Plymouth PL6 8DH, UK

A. N. Kingsnorth
Department of Surgery, Peninsula Medical School, Plymouth PL6 8BU, UK

Introduction

Initial burden of surgical disease estimates predict that surgery can address 12 % of disability adjusted life years (DALYs) that occur in the Americas [1], with inguinal hernia repair being one of the most commonly performed operations. Ecuadorian national hospital exit surveys indicate that inguinal hernia is the fourth leading cause of morbidity among male discharges (11.2 per 10,000 people), and seventh overall [2]. Longstanding inguinal hernias are common in Latin America, with some remaining unrepaired for decades [3]. No data have been published on what proportion of hernias become strangulated or how many are repaired as emergencies, although there is a disproportionate need for treatment in rural areas [4, 5]. In 1990, the population prevalence of inguinal hernias in Esmeraldas Province Ecuador was estimated at 4.3 % [6].

Access to surgical services is improving in Ecuador, complementing successes with other public health priorities [7] and a strengthening the health system overall. However, despite being a middle-income country, economic growth masks a high level of social inequality (Gini coefficient 54.4) [8], with 665,390 people (4.6 % of the population) living on <$1.25 per day, and a poverty headcount ratio of 32.8 % using the national poverty line [9]. People do not always know when to seek surgery, especially within low-income communities. Therefore there is a record of under-treatment of some common conditions (trauma, hernia, appendix, and gall bladder pathologies), and over-treatment of others (cesarean rates well above the WHO guidelines of 5–15 %) [10, 11]. International and national collaborations are innovating solutions to improve appropriate coverage of surgical services and supplies, such as low-cost mosquito net mesh for Lichtenstein hernia repair [12–15] and local anesthesia [16]. There is an increasing recognition of the importance of managing the unmet burden of surgical disease in international health policy [17].

Cost-effectiveness analysis (CEA) is one type of evidence informing prioritization decisions between unrelated healthcare interventions. In low and middle income countries (LMICs), only one study exists on the cost-effectiveness of hernia repair [18], although the Disease Control Priorities Project second edition (DCP2) advocates it as an essential service of district hospitals [1].

Our study assesses day-case Lichtenstein inguinal hernia repair with mosquito net mesh at a rural hospital in northwestern Ecuador. While the Ministry of Health provides modified Bassini repair at nearby hospitals in Quinindé and Santo Domingo, and several private clinics exist in the area, persistent barriers to access prevent many people from receiving surgery promptly if at all. Therefore, comparison is made to a modeled no-treatment scenario, also similar to generalized cost-effectiveness analysis [19].

Methods

Operation Hernia is a United Kingdom (UK) based non-governmental organization, that has expanded from a link between hospitals in Takoradi Ghana and Plymouth England to sites in more than 12 countries. During July 2010, in a two-week mission that combined attributes of brigade and minimalist models [20], an Anglo-American team repaired hernias at Corporacion de Salud Padre Damian (CSPD) in La Independencia Ecuador and at a local clinic. A second two-week mission was conducted at CSPD from November–December 2010 by a Spanish team. Patients were identified through personal communication, radio and flyer campaigns, community announcements, medical referrals, and patient consultations at the Ministry of Health (MoH) sub-center in La Concordia (Area 23). Given 15 years of mosquito net surgery in India and acceptable mesh characteristics [14], no internal review board (IRB) approval was necessary for this study.

Clinical presentation, diagnostic tests, patient demographics, medical history, and health state valuations were recorded prior to surgery. Hernias were assessed by operating surgeons, and inguinal hernias were classified preoperatively based on reducibility of the hernia (H1–H4), hernia size (a–c), and obesity of the patient (F1–F4) (Table 1) [21, 22]. In the second mission, European Hernia Society (EHS) intraoperative classifications were included [23]. Lichtenstein repair was performed for all cases, using sterilized mosquito net mesh (donated by Dr. Ravi Tongaonkar) or polypropylene commercial mesh, and nylon suture. Exclusion criteria for local or spinal anesthesia were young age, groin infection, diabetes, or if the hernia was irreducible and significant in size. Patients were discharged on the same day, and passive follow-up for wound checks was organized at CSPD and the MoH subcenter.

Health outcomes were calculated as DALYs averted with equations from the global burden of disease (GBD) study [24], discounted at 3 % with no age weighting in the reference case, consistent with DCP2 methods [25, 26]. Average life span data for each age were taken from the sex-specific West Life Table level 26 in the reference case to promote equity in international decision making. If a patient had multiple hernias, life expectancy associated with the more severe grade hernia was used. Assuming that QALY weights = 1 − DALY weights [27], values for open flat mesh repair with no recurrence [28] were tested for postoperative states, consistent with value of surgical care (VSC) methods [17]. In the absence of GBD values for inguinal hernia, a disability weight for untreated hernia (0.3) was based on expert opinion, as an approximate midpoint between 0.1 and 0.463 [29–31], and variations were tested in sensitivity analysis. Mortality for untreated hernias (1 %) was based on expert opinion [31], with expected life spans based on assumed (Table 1) or expected life span for the patient's age (if shorter). The authors can provide a spreadsheet for readers to adjust according to their own assumptions.

Costs were calculated from a provider perspective in the reference case, consisting of variable costs (volume-driven), and fixed costs (independent of patient volume). Provider perspective costing accounted for costs borne by Operation Hernia and the local health system, outlined in Table 2. Other costs included patient costs (out-of-pocket costs and treatment seeking expenditures) and capital costs. Capital costs of CSPD only were included, because a normal table was used in the second mission to double surgical capacity; the same table could have been used in the first mission. Societal perspective costs combine

Table 1 Metrics used to value health outcomes

Classification[a]	Probability of death if left untreated (%)	Disability weight	Years lived if left untreated	Number (%) of hernias						Definition
				Total		Mission 1		Mission 2		
H1	1	0.3	20	44	44 %	14	29 %	30	59 %	Reduces spontaneously when patient is lying down
H2	1	0.3	20	28	28 %	18	37 %	10	20 %	Groin only, reduces completely with gentle manual pressure
H3a/b	1	0.3	15	20	20 %	13	27 %	7	14 %	Inguino-scrotal, reducible with manual manipulation
H3c	1	0.3	15	3	3 %	2	4 %	1	2 %	
H4a	1	0.3	10	4	4 %	2	4 %	2	4 %	Irreducible
H4b/c	1	0.3	10	1	1 %	0	0 %	1	2 %	
Total classified				100	100 %	49	100 %	51	100 %	

[a] Inguinal hernia classification from Kingsnorth (2004) [21], with sizes defined in Sanders et al. (2008) [22] as a: <10 cm, b: 10–20 cm, c: >20 cm

provider and patient perspectives. Cost components from previous years were inflated to 2011 values using GDP deflators according to where the item was purchased [9].

Physical units for variable cost components were recorded prospectively. Unit costs were obtained from the CSPD pharmacy, purchasing records of participating physicians, the WHO Choosing Interventions that are cost-effective (WHO-CHOICE) project [32], and catalog prices from local and international medical suppliers. Following treatment, a survey was administered to patients to measure out-of-pocket expenditures and indirect costs.

To the extent possible, fixed costs reflect "replacement costs" not "opportunity costs," consistent with textbook recommendations [33], although replacement costs were not available for several variables, such as building construction. Fixed costs were annualized according to the life span of the component, based on values from WHO-CHOICE, observed life span, or an assumption of 10 years [32, 34]; then pro-rated to the number of days of the missions. Furniture, equipment, and laboratory costs were based on standard requirements for a facility found in the region and based on prices of local suppliers. Costs for land purchase and hospital construction were estimated by the former hospital director. Costs of facility renovations by Medicus Mundi Andalucia were included. Utilities and maintenance costs for building and equipment were estimated by the hospital administrator. The cost of a radio campaign and informational flyer-based media campaign was included. Personnel costs were based on WHO-CHOICE estimates for visiting surgeons [32] and CSPD expenditures from the previous year for hospital staff salaries.

For missing data points, values were imputed where a standard of care existed (e.g., for minor hernias, local anesthesia in the first mission, spinal anesthesia in the second mission). Otherwise, results are reported using the number of patients that had data in the denominator (e.g., primary hernia, daily living limitation). If pain and vomiting were not reported, they were assumed not to be experienced by the patient.

Incremental cost-effectiveness ratios (ICERs) were calculated comparing hernia repair to a hypothetical no-treatment scenario, evaluated against per-capita Gross National Income to define cost-effectiveness [35]. Variation in patient-level costs and health outcomes was accounted for using probabilistic sensitivity analysis (Monte–Carlo simulation with 10,000 iterations). Bootstrapping was used to calculate confidence intervals as normal quaintile plots, and Shapiro–Wilk tests indicated that data were not normally distributed [36]. Cost-effectiveness acceptability curves were generated according to different DALY formulations and 25 % variations in cost (Figs. 1, 2) [37]. Another curve plots ICERs against alternative values for the disability weight (Fig. 3). Scenario analysis was conducted to test the impact of different life tables, costing perspectives, adjustment to International dollars (I$) [32], including travel and accommodation costs, considering disability after intervention, providing treatment within one year of onset, reducing premature mortality to 0 %, and different DALY formulations. World Health Organization (WHO) AMRO D life tables from 1999 [38] were tested, as were 2009 Model Life Tables for Ecuador [39].

Results

A total of 102 patients with inguinal hernias underwent surgery, including 14 with bilateral hernias. The median age of patients was 47 years (range: 4–85 years), compared to an average life span in Ecuador of 75.4 years [9]. Some 84 (82 %) of these patients were male, and 43 of them (42 %)

Table 2 Costs for cost-effectiveness analysis

Cost component	Value	Proportion (%)
Provider perspective patient costs		
Laboratory tests[a]	**$16.86**	**2.9**
Intraoperative costs	**$62.47**	**10.8**
Nondisposable[b]	$21.26	34.0
Disposable[c]	$14.42	23.1
Anesthetics and analgesics[d]	$15.63	25.0
Mosquito net mesh[e]	$0.01	0.0
Sutures	$5.19	8.3
Dressing	$5.96	9.5
Postoperative costs	**$2.21**	**0.38**
Personnel	**$496.51**	**86**
Total provider perspective costs	**$578.05**	**100**
Additional costs[f]		
Local anesthesia	$0.00	
Spinal anesthesia	$6.03	
General anesthesia (infusion pump)	$9.38	
General anesthesia (machine)	$23.95	
Patient perspective costs		
Indirect costs	**$8.96**	**11**
Direct costs	**$74.34**	**89**
Surgery[g]	$55.14	74
Medical consultation	$1.38	2
Laboratory tests	$8.27	11
Postoperative medicine	$10.00	13
Total costs	**$83.30**	**100**
Fixed costs		
Facility construction and maintenance	$900.70	50
Improvements	$79.82	4
Furniture and equipment	$432.91	24
Utilities[h]	$189.73	11
Publicity	$192.98	11
Total	$1,796.13	100

[a] Biometric, glucose, creatine, coagulation factors, electrocardiogram. Biometric and coagulation factor tests were required for all patients. Glucose, creatine, and electrocardiograms were performed where necessary

[b] Instrument set, gowns and drapes, surgical shoes

[c] Gloves, mask, hat, shoe covers, Savlon + alcohol, gauze, cotton, 20 ml syringes, needle 21, #10 blades, sutures, dressing

[d] Lidocaine, bupivacaine, fentanyl, propofol, ketamine, amoxicillin, paracetamol, ibuprofen, midazolam, metanizol, metronidazole, ketorolac

[e] Polypropylene commercial mesh used in the second mission costs $40 minimum in Europe (Kingsnorth et al. 2011), $100 in Ecuador

[f] These costs are calculated per patient that received each type of anesthesia, not average across all patients. Add these figures to total provider perspective costs to calculate totals according to anesthesia types

[g] $50 maximum charged per surgery during missions, $30 in the first mission (uninflated)

[h] Utilities consisted of water, telephone, and electricity; accounting for a back-up diesel generator and operating room cleaning materials

Bold highlights major cost component headings, with sub-components not in bold

were fathers, with an median family size of 4 (range: 1–20). Patient occupations were recorded as follows: 25.0 % farmers, 20.8 % tradesmen, 12.5 % professionals, 12.5 % domestic workers, and 29.2 % other ($n = 96$).

Table 1 presents numbers and frequencies of inguinal hernia classifications; 96 % were primary hernias ($n = 80$), 94 % were reducible, and none were acutely obstructed or strangulated. Some 84 % of patients reported pain before

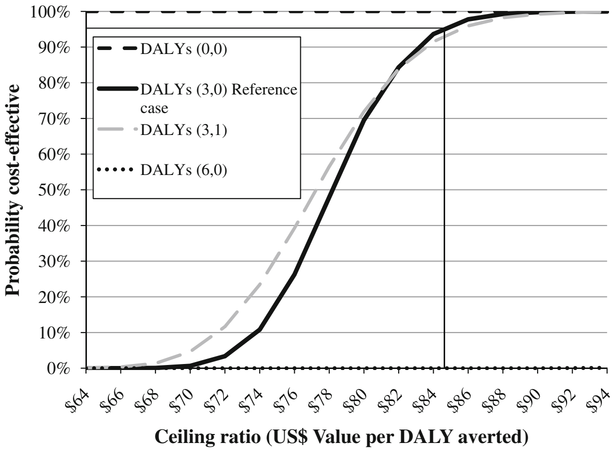

Fig. 1 Cost-effectiveness acceptability curves, with variation according to DALY formulation

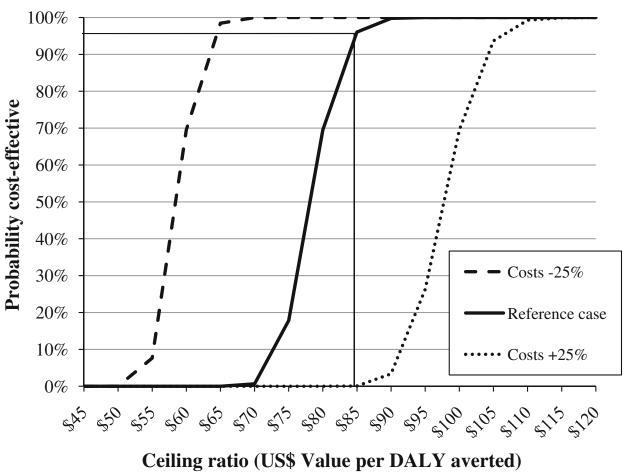

Fig. 2 Cost-effectiveness acceptability curves, with variation according to 25 % differences in total costs

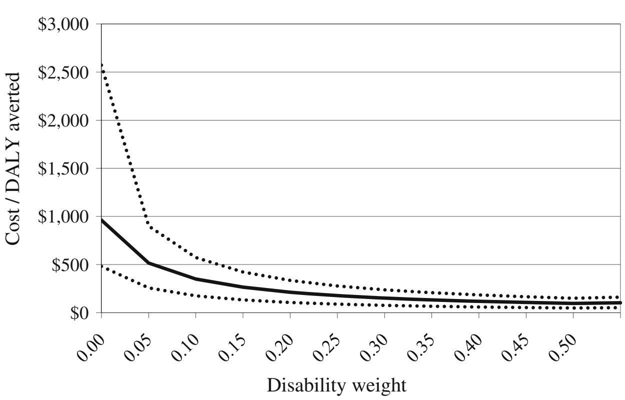

Fig. 3 Sensitivity analysis testing variation in the disability weight (with 95 % confidence interval)

surgery, and 6 % reported vomiting. By EHS classifications ($n = 53$), 68 % were lateral, 38 % were <1 cm, 43 % were <3 cm, and 19 % were >3 cm. The median time with a hernia was 4 years (maximum: 60 years). Some 58 % of patients reported activity limitations such as recreation, occupation, or procreation, and 24 % reported two or more limitations. Some 13 % of patients reported having a daily living limitation affecting bathing, cooking, walking, or housework ($n = 76$).

Mosquito net mesh was used in 92 % of hernia repairs in the first mission, with polypropylene mesh used in the second mission. The remaining 8 % of hernias treated in the first mission were corrected by herniotomy. Local anesthesia was used for 82 % of cases in the first mission, with spinal anesthesia used for 89 % of the cases in the second mission. General anesthesia with 1 % propofol through an infusion pump was used in 8 % of operations overall, supplemented with sevoflurone via an anesthesia machine if necessary. The median time of each operation was 55 min (range: 20 min–2 h) ($n = 81$).

In reference case calculations, 639 total DALYs (3.0) were averted, 97 % of which were attributable to Years Lived with Disability (YLDs). Choice of life table had a moderate effect on results, with results ranging from 576 to 652 DALYs (3.0) averted (Table 3). Varying discounting from 0 to 6 % significantly affected results (1,079 to 449 DALYs averted). Introducing age weighting had a negligible effect on DALYs averted, and assuming 0.054 DALYs per year after surgery decreased DALYs by 5 %. A program that addresses hernias during the same year of onset would avert 4 % more DALYs, given the younger ages at which people would otherwise die. Assuming no mortality from untreated hernias had a negligible effect.

Treatment-seeking factors are presented in Table 4, with reasons for seeking surgery evenly distributed given the diversity of publicity strategies. Surgery was affordable, with only 21 % of patients receiving institutional financing, which was based more on social inclusion than on poverty ($n = 72$). Patients spent a median $2 on transportation (Table 2), mostly by bus from La Concordia, with extreme cases traveling from Otavalo and Guayaquil. Twenty-four patients incurred expenses for food, and five patients stayed in the hospital overnight, one for two nights. Patients reported a median $87.43 in direct out-of-pocket costs. Median variable costs from the provider perspective were $562.91 per patient. These costs were almost exclusively intraoperative and personnel. A postoperative check-up was provided without charge to patients (US$2 value considered in provider prospective costs). The incremental difference of spinal anesthesia versus local anesthesia was $235 per patient (Table 5). The cost of a standard mission with 120 patients, 8 days, and 5 physicians is presented in Table 6.

Cost-effectiveness was calculated from provider, patient, and societal perspectives (Table 3). From a provider perspective, each surgery cost an average of

Table 3 Cost-effectiveness results

Reference case	Cost per patient			DALYs averted			Incremental cost-effectiveness ratio			
	Expected value	Confidence interval		Expected value	Confidence interval		Expected value	Confidence interval		Proportion of baseline
DALY (3,0) Provider costs West Life Table	$499.33	$490.19	$526.03	6.39	6.22	6.84	$78.18	$75.86	$85.78	Baseline
Sensitivity analyses										
DALY (3,0) Provider costs Regional Life Table	$499.33	$490.19	$526.03	5.76	5.60	6.24	$86.71	$85.96	$96.22	111%
DALY (3,1) Provider costs Regional Life Table (I$)	$924.75	$907.20	$975.19	6.08	5.85	6.75	$152.00	$145.91	$172.55	194%
DALY (3,0) Provider costs National Life Table	$499.33	$490.19	$526.03	6.52	6.37	6.94	$76.61	$76.37	$83.49	98%
DALY (3,1) Provider costs National Life Table (I$)	$924.75	$907.20	$975.19	6.53	6.32	7.19	$141.51	$136.11	$159.32	181%
Sensitivity analyses West Life Table										
DALY (3,0) Patient costs	$118.79	$110.28	$143.72	6.39	6.22	6.84	$18.60	$17.24	$22.80	24%
DALY (3,0) Societal costs	$615.46	$603.39	$650.40	6.39	6.22	6.84	$96.37	$93.36	$105.90	123%
DALY (3,0) Provider costs (I$)	$924.75	$907.20	$975.19	6.39	6.22	6.84	$144.80	$140.37	$158.80	185%
DALY (3,0) Provider costs (incl. travel, accommodation)	$622.26	$613.12	$648.96	6.39	6.22	6.84	$97.43	$94.74	$106.34	125%
DALY (3,0) 0.054 disability after intervention	$499.33	$490.19	$526.03	6.04	5.90	6.49	$82.65	$80.14	$90.64	106%
DALY (3,0) surgery same year as hernia	$499.33	$490.19	$526.03	6.65	6.53	7.02	$75.09	$73.70	$81.83	96%
DALY (3,0) No premature mortality	$499.33	$490.19	$526.03	6.33	6.16	6.80	$78.90	$78.52	$86.87	101%
DALY (0,0)	$499.33	$490.19	$526.03	10.79	10.42	11.90	$46.29	$44.42	$52.06	59%
DALY (6,0)	$499.33	$490.19	$526.03	4.49	4.35	4.91	$111.18	$107.50	$123.18	142%
DALY (0,1)	$499.33	$490.19	$526.03	10.50	10.02	11.91	$47.53	$45.32	$55.11	61%
DALY (3,1)	$499.33	$490.19	$526.03	6.47	6.23	7.14	$77.15	$74.21	$87.18	99%

DALY = Disability adjusted Life Years (r,K), *r* = discount rate, *K* = age-weighting modulating factor, *I$* = International Dollars

US$499.33 (US$490.19–$526.03) and averted 6.39 DALYs (6.22–6.84). This led to an ICER of US$78.18/DALY averted (US$75.86–$85.78) according to DALY (3,0) calculations and conservative assumptions, which compares favorably to a ceiling ratio of US$3,850 [9]. Acceptability curves show that this result is cost-effective with 95 % certainty if the ceiling ratio is above US$84.50/DALY averted, and that this result is robust to sensitivity analyses on DALY formulations and 25 % variations in cost (Figs. 1, 2). Converting to international dollars and using a regional life table, surgery cost I$152.00/DALY averted (I$145.91–$172.55). Surgery remains cost-effective even if only 0.13 DALYs are averted per patient. If disability weights are set at zero, surgery is cost-effective based on 1 % mortality alone (Fig. 3). Assuming no premature mortality has a negligible effect on cost-effectiveness. Using parameterizations to make results comparable to a previous analysis from Ghana [18], the number of DALYs (3.0) averted decreases from 639 to 446, and the incremental cost-effectiveness ratio increases by 43 %.

Discussion

Lichtenstein repair of inguinal hernia was cost-effective relative to no treatment at a rural hospital in northwestern Ecuador. Surgery was cost-effective even if 49.2 times fewer DALYs were averted relative to reference case calculations. The first mission used local anesthesia, consistent with evidence and recommendations [16]. Two patients were hospitalized, and three patients stayed overnight on their own volition. Use of mosquito net mesh in the first mission instead of manufactured mesh provided substantial cost savings [13, 14]. Patient demand was high due to provision of care by foreign surgeons, effective collaboration with the local Ministry of Health, effective

Table 4 Treatment-seeking factors

	Median (range)	
Distance traveled (km)	11 (1–560)	
Time since medical consultation, months	4 (0–108)	
	Number	Percentage
Treatment-seeking factors		
Radio publicity	55	11.7
Medical recommendation	49	10.4
Personal recommendation	65	13.8
Pain	48	10.2
Interference with daily activities	47	10.0
Flyer	56	11.9
Price	47	10.0
Church announcement	48	10.2
Size of hernia	46	9.8
Other[a]	10	2.1
Treatment was affordable	89	100
Manage costs		
Self	57	63.3
Family	16	17.8
Loan	14	15.6
Other	2	2.2
Services forgone due to cost	4	8.2

[a] Saw television advertisement, knew from previous mission, or was already in hospital

Table 5 Incremental comparison of local and spinal anesthesia

Component	Spinal anesthesia	Local anesthesia
Surgeon[a]	$224.84	$224.84
Anesthetist[a, b]	$224.84	$0.00
Lidocaine	$0.19	$1.07
Buvipicaine	$0.44	$2.91
Fentanyl	$0.16	$0.52
Propofol	$1.72	$0.14
Ketamine	$3.57	$0.00
Non-disposable	$21.26	$21.26
Disposable	$14.42	$14.42
Needles (25G or 3–21G)	$2.29	$0.23
Spinal equipment[c]	$6.42	$0.00
Total	$500.16	$265.37

[a] Calculated from weighted average of WHO-CHOICE figures [32]

[b] An anesthetist is not necessary for local anesthesia patients. Intravenous fluid is not essential, and conversions to general anesthesia are rare (appx 0.1 % of cases), and is handled by the 'Duty Floor Anesthetist' if available

[c] Cannula, intravenous line, sterilized gloves, asepsis kit

advertising, high hernia prevalence, low out of pocket costs, and a population with low income. These factors allowed fixed costs to be widely distributed. Standard laboratory tests included a full blood count, glucose tests for patients with suspected diabetes, and coagulation factors and electrocardiograms (EKG) for patients considered for general anesthesia. Propofol 1 % was used for general anesthesia as it is less expensive than most gases, and an infusion pump is less expensive than an anesthesia machine. Tailored washable gowns and drapes were similar in price to disposable varieties, were stored for future missions, and are expected to provide use for one year of surgeries. Minor cost-savings were achieved by using one syringe and three needles per surgery with local anesthesia; one oral amoxicillin before surgery instead of more expensive antibiotics and needles; one mask, hat, and pair of shoe covers all day (or inexpensive surgical shoes); and a spray bottle for iodized alcohol or Savlon.

Table 6 Cost of a standard mission 120 patients, 8 days, 5 physicians

Component	Cost
Flights (6 people)	$5,500
Travel to/from airport (in country)	$200
Travel to/from airport (at home)	$240
Accommodation (local hotel)	$720
Publicity (radio + flyers)	$110
Mosquito net meshes	$1.20
Anesthesia materials	$730
Hospital medicines and materials	$1,600
Surgical instruments	$1,050
Sutures (20 boxes)	$105
Gowns and drapes	$720
Diathermy machine	$3,585
Total	$14,561

The program provided training for visiting and Ecuadorian practitioners [40], with the local Ministry of Health partnering with Operation Hernia, and a formation of a similar organization called Cirujanos en Acción. Many operations were provided, high quality standards were maintained, responsibility for equipment and supplies was shared, and opportunities for teaching were maximized.

Incentives for surgeons and trainees to participate in surgical missions include humanitarian appeal [41], medical appeal (training in the latest techniques) [40], career development appeal [42], political appeal [as part of the WHO Global Initiative for Emergency and Essential Surgical Care (GIEESC) and Alliance for Surgical and Anesthesia Presence (ASAP)], and personal appeal (the privilege of serving an underserved population; collaborating with hard-working staff) [43]. These factors should be considered when comparing hernia surgery with other interventions that should receive investment in the health sector; along with cost-effectiveness, what society considers to be a priority, horizontal and vertical equity, fairness in financing, and burden of disease [44].

Compared to our previous analysis [18], this evaluation had a more robust approach to costing. Data from two missions were used, making possible comparisons of standard practice used by different teams. The number of DALYs averted was less than in Ghana (4.46 per person in Ecuador; 9.3 per person in Ghana with previous parameterizations; 6.93 and 7.49 with reference case parameterizations from this report) because 72 % of hernias were H1 or H2 (33–40 % in Ghana) [18, 22]. Years with hernia were 6 (H1), 7 (H2), 11 (H3), and 5 (H4) in Ecuador; similar to Ghana. Costs represent middle-income instead of low-income country levels (the World Bank has since reclassified Ghana as lower middle income). However, given the higher Ecuadorian per-capita GNI, the probability that the intervention was cost-effective was very high in both settings. Lost work time was less than in Ghana, limited mainly to treatment-seeking, totaling $2,079 in lost wages not accounted for in cost-effectiveness results. On a larger scale, 500,000–700,000 hernias are repaired in the United States every year at a cost of $3 billion for surgery and time away from normal activities, and 800,000 people with hernias choose to not have surgery per year [45]. Indirect costs or productivity gains of hernia repair may have been more substantial than were recorded.

The present study had several limitations. Most patients came from towns or cities, and selection bias may have influenced the case mix. Recurrence rate may impact cost-effectiveness [46], and although no patients returned to the hospital, pooled analysis of randomized trials indicates that it can be expected to be 2.329 % for open mesh repair [46]. Disability weights were based on expert opinion, which has been argued to be sufficient if results are robust to wide variation in sensitivity analysis [47]. Data do not indicate how long patients spent with each hernia grade, progressing from H1 to H4, or what proportion of patients died before treatment could be provided. We attempted to collect EQ-5D data on patient preferences, but illogical results according to hernia grade suggested that our data were subject to bias, or that other factors besides hernia grade were stronger influences on patient preferences.

Assuming 1 % mortality for untreated patients may be overly conservative. Of 699 patients presenting for scheduled hernia surgery in Glasgow, Scotland, 6.5 % of inguinal hernias were irreducible after 1 year, and 30 % of them were irreducible at 10 years [48]. The mortality rate associated with strangulation is documented at 11–13 % [49]. If all irreducible hernias eventually strangulate without surgery, the result would be 3–4 % mortality. For patients with hernias over 10 years, mortality rates may be even higher [50].

A common concern about expanding the availability of surgery is that broader availability will make it necessary to lower the standards of care [51]. This is not the case with mosquito net mesh and local anesthesia [14, 16]. Few complications arose following the mission, and all were treated conservatively by the visiting team and local practitioners. Hospitalization was required for one patient with ileus and one patient who required immediate reoperation. Based on passive uptake, 4 % of 51 patients returned with hematomas, 4 % with swelling, 2 % with numbness, and 2 % with wound infections that were managed successfully with antibiotics. These findings were comparable to our study in Ghana [18], although results from both studies are lower than evidence from Scotland [52, 53], likely because not all patients with complications in our series returned for examination.

This analysis did not consider the costs of managing complications; however, they are expected to be negligible due to their infrequency and the fraction of nurse time required. Fourteen months later, no recurrence or mesh rejections have been reported.

We suspect that the unmet need for hernia repair exceeds the met and unmeetable need in LMICs [17], and that finding solutions to make surgery available and affordable should be a priority of national and international health policy. Hernia repair is free under Ecuador's 2008 Universal Health Plan; however, local hospitals have long waiting lists for operations. Against Ramsey pricing theory [54], commercial mesh costs $40 in the UK but $100 or more in Ecuador, and around 80 % of patients opt for Bassini treatment to avoid the $100 cost of mesh, accepting or ignoring risks of recurrence.

Our study provides evidence that Lichtenstein method hernia repair can be cost-effective through international partnerships in the Latin American context. Local anesthesia and mosquito net mesh are less costly and as effective as spinal anesthesia and commercial mesh. Both should be used on a wider scale. While medical missions are short-term, they can be a cost-effective and financially accessible option for patients with limited resources. Strengthening ambulatory surgery in general is a valid priority for poor countries, hernia repair being an excellent example. Scaling up surgical services in Ecuador is highly recommended.

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