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Cost-Effectiveness Analysis of Mesh Repair for Inguinal Hernia During a Humanitarian Surgical Mission in Rural Nigeria

Florian Oehme[1], Frank J. P. Beeres[1], Lana Fourie[1], Eze Tobias Okwudili[2], Peter Nussbaumer[3]

[1]*Departement of General Surgery, Cantonal Hospital Lucerne, P.O. Box 6000; Spitalstrasse 16, CH-6000 Luzern, Switzerland*

[2]*Departement of General Surgery, St. Mary's Hospital Okpoga. P.O Box 36, Okpoga, Benue State, Nigeria*

[3]*Department of Surgery, Lachen Hospital, Oberdorfstrasse 41, CH-8853 Lachen, Switzerland*

Background: Humanitarian short-term surgery missions remain under debate, even though the proportion of the burden of surgical diseases around the world that could be treated based on surgery is constantly rising. The primary objective of this study was to prove the cost-effectiveness (CE) of a hernia repair–teaching mission in the rural setting of Nigeria.

Methods: We present a CE analysis (CEA) of a 2-week surgery mission performing inguinal hernias with mesh repair according to the Lichtenstein maneuver. All data were collected prospectively. The contribution to the local health system was measured based on the disability-adjusted life years (DALYs). Further on, the CEA was analyzed and separated for surgeons from Nigeria and Europe, respectively.

Results: During this mission a total of 107 patients with 123 hernias were treated. An average of 6,61 DALYs per patient were averted. The total costs for the mission team amounted to $8485.26, with a total of $19,210.73 from a societal perspective. Single-procedure costs amounted to $198.87 per patient, with $39.35 per procedure from a patient perspective. The CEA showed $31.04/DALY averted from a societal perspective, $13.71/DALY averted from a provider perspective, and $6.81/DALY averted from a patient perspective. This was well below the threshold of $2790 (gross domestic product per capita). Sensitivity analysis showed robust results.

Corresponding author: Peter Nussbaumer, MD, Spital Lachen AG, Oberdorfstrasse 41, CH-8853 Lachen, Switzerland.
Tel.: 0041 (0) 55 451 32 06; E-mail: peter.nussbaumer@spital-lachen.ch

Conclusion: With these results we proved CE and remained about 90 times below the threshold of the gross domestic product per capita.

Key words: Humanitarian Surgery – Inguinal hernia – Nigeria – DALY – Cost effectiveness analysis – Mesh repair

Raising awareness in global health care politics concerning the necessity of surgery in low- and middle-income countries (LMICs) during medical short-term missions (MSTs) has been a tilt against windmills for years.[1]

Humanitarian surgery in LMICs has to deal with 2 traditional misperceptions. First, surgery is considered an intervention needed once a disease has already occurred rather than a preventative tool. Even though operations are only performed once the disease already exists, one could argue that, for example, inguinal hernia repair yields a preventive character concerning further increase in size and possible incarceration. Secondly, operative interventions are considered expensive, and thus not cost-effective.

The latter statement was proved wrong in recent analyses[2–6] showing a high level of cost effectiveness (CE) during MSTs for inguinal hernia repair. But because these trials have considerable limitations in generalizability, researchers should be empowered to present data on the CE of short-term MSTs dealing with inguinal hernia repair from various regions of the world.[4]

Compared with other regions, the amount of disability-adjusted life years in Africa is high,[7] with a considerable proportion of the burden caused by inguinal hernias. Thus, the surgical capacity of rural areas in particular needs to be strengthened.[8] Yet, there is a considerable lack of available data concerning surgical missions to very rural regions of Africa, such as Nigeria.

With respect to current literature, the proportion of physicians and surgeons required to serve the needs of the population in sub-Saharan Africa is high.[5,9,10] Because it is not realistic to expect national governments to solve this structural and economic problem in the near future, development aid needs to focus on this issue.[11,12] A feasible way to improve local surgical capacity could be by promoting MSTs to deliver surgical care to the austere regions of Africa.[13]

On the other hand, surgical literature concerning humanitarian missions needs to prove their CE to gain popularity among sponsors and foundations.[14,15]

To our knowledge, to date no CE analysis (CEA) has been performed in urban or suburban, let alone rural areas of Nigeria. Furthermore, local analysis of hernia repair rates in Nigeria is sparse, with only some results from the universities and urban regions.[16]

The main objective of this study was to present a CEA in the rural setting of Okpoga, Nigeria. We hypothesize that the CE of teaching missions in hernia repair is feasible. Moreover, we want to encourage medical scientists to present their analysis from various areas around the world to strengthen the position of surgery in public health policy as called for by Debas *et al* (Bellagio Essential Surgery Group).[8,13]

Methods

This article was written in accordance with the STROBE statement.[17]

Study population/hospital

We present results from a 2-week MST that treated symptomatic inguinal hernias in Okpoga (Nigeria) during October 2016.

These missions were first initiated in 2011 and are performed 2 to 3 times a year on a regular basis, each mission lasting 2 weeks. During all MSTs the mission teams collaborate with the Catholic diocese of Otukpo, which is responsible for St Mary's hospital. The hospital is run by the Sisters of Nativity and serves a population of 150,000. A varying number of doctors, normally between 2 and 4, with little or no surgical training are employed by the hospital. All of the doctors have had surgical training ranging from 6 months to 1 year.

Eligibility of patient data concerning the CEA was considered for all patients undergoing operation for inguinal hernias during the above-mentioned period of time. Data were collected by a single surgeon in a prospective manner and included basic patient characteristics, classification of hernia, medical history, and type of anesthesia. Hernias were classified using the modified Kingsnorth classification[18] and were treated in accordance with the Lichtenstein procedure[19] using a sterilized mosquito net mesh (MNM). Previously described by Shillcutt *et al*,[3] those MNMs have shown results comparable to those of commercial polypropylene net meshes,[6,20] which encouraged

Table 1 Hernia distribution and basic patient characteristics

Classified hernia[a]	No. of patients	Amount (%)	Age, SD		Average DALYs averted (95% CI)
			Male, y	Female, y	
H1	26	31 (25.2)	41.5	51.3	5.61 (4.28–6.94)
H2	35	39 (31.7)	45.4	45.5	5.34 (4.49–6.19)
H3					
A	13	15 (12.2)	41.8	61.0	5.19 (3.37–7.01)
B	8	10 (8.1)	36.3	40.0	6.86 (5.82–7.90)
C	2	2 (1.6)	55.0	—	3.58 (0–24.05)
H4					
A	5	6 (4.9)	51.0	—	4.36 (1.19–7.52)
B	3	3 (2.4)	55.7	—	3.97 (0–14.11)
C	5	7 (5.7)	49.3	64.0	3.67 (1.18–6.15)
Pediatric hernia	10	10 (8.1)	6.9	—	10.37 (10.19–10.55)
Total	107	107 (100)	39.7	50.24	5.78 (5.20–6.35)

[a]Hernia classified according to Kingsnorth,[18] with additional size defined by Shillcutt *et al*.[3]

the mission team to perform this analysis without review board approval.[2,3]

Costs

Costs are calculated from 2 different perspectives in this CEA and according to the suggestions from Murray *et al*[21] and Creese[22]:

Provider/hospital perspective (societal costs)

We compiled all fixed costs borne to the mission team either prior to the mission (visa, taxes, flight ticket) or during the mission (accommodation, supplies).

Fixed costs borne by St Mary's Hospital consisted of salaries, facility construction, equipment, and overhead costs (water, electricity, diesel generator).

Because the latter costs were not available, we performed the approach suggested by Creese *et al*[22] using a rental fee representing a comparable area rented during the trial in central Abuja with available data.

Salaries were calculated based on national standardized salaries (public information), although salaries in Okpoga are significantly lower compared with the capital in Abuja.

Variable costs (volume-driven) were added (medication, anesthesia, disposable/nondisposable material) using standard material cost lists provided by the local pharmacy of the mission team (Hospital Lachen; Cantonal Hospital Lucerne).

Patient perspective

The components of patient perspective costs consist of "intervention-seeking costs" and "intervention costs" themselves.[22] We assessed the "intervention-seeking costs" using standard transport costs of public transportation.[23]

The "intervention cost" is 10,000 Naira ($31.77; exchange rate for February 15, 2017) per inguinal hernia repair and 15,000 Naira ($47.66) for bilateral repair. All costs were converted to US dollars using current exchange rates.[24]

Disability-adjusted life years/outcome

The disability-adjusted life years (DALYs) averted are calculated according to the World Health Organization approach using the global burden of disease study.[21] The results are presented according to Fox-Rushby and Hanson.[25] DALYs could be described in a simplified equation as years lived with a disease (YLD) and summed up with years that are lost due to premature mortality (YLL). We calculated the averted DALYs with a discount rate of 3% for each following year, an age-weighting factor with a β of 0.04 and a disability weight of 0.3 according to Shillcutt *et al*.[3] The life expectancy was calculated using the life span data for both age and sex specifically from the World Health Organization's model life tables for Nigeria.[26] Sensitivity analyses were carried out according to the recommendations of Fox-Rushby and Hanson.[25]

CE was assumed if the amount of $/DALY averted was below the gross domestic product per capita.

Results

During this mission we treated 107 patients with a total of 123 hernias. The distribution and basic patient characteristics are presented in Table 1.

Table 2 Sensitivity analysis of DALYs averted

	DALYs averted	DALYs/patient averted
DALY (0.03;1;0.04)[a,b]	619.05	5.78
DALY (0.03;0;0)[b]	564.24	5.27
DALY (0;1;0.04)[b]	952.08	8.9
DALY (0.06;0;0)[b]	398.26	3.72
DALY (0.03;0;0)[b] without premature mortality	617.97	5.77
DALY (0.03;1;0.04)[b] for each hernia calculated	706.99	6.61

[a]Reference analysis.

[b]Numbers in parentheses are (r) discount rate, (k) age-modulating factor, and (β) parameter for age-weighting function.

Mean age of our patients was 42.2 years, with a median life expectancy according to the World Health Organization's model life tables for Nigeria[26] of 54.5 years (male, 53.4 years; female, 55.6 years). The male to female ratio was 76.6%:23.4%, which was comparable with other missions performed in Okpoga (range of female patients, 13.9%–30%).

Anesthesia was carried out using either local, spinal, or general anesthesia, accounting for 55.1%, 28%, and 9.3%, respectively. A total of 7.5% of all patients with an initial local anesthesia needed an additional analgesic sedation with ketamine.

A total of 52.4% of all operations were performed by Nigerian doctors being assisted by one of our team members. Moreover, 20.6% of these operations were performed solely by Nigerian staff. In contrast, only 13% of the operations were performed solely by Swiss surgeons. In total, Nigerian staff members participated in 87% of all operations either as the primary surgeon or at least as first assistant.

A total of 619.05 DALYs (3.0;1;0.04) were averted, accounting for 5.78 DALYs averted per patient. Most DALYs were due to YLD, and the minority were due to YLL (1.09 YLL; 0.18%). Thus, even if premature mortality would have been set to zero, no significant influence was revealed based on the YLL.

The analysis of all hernia surgeries performed (all DALYs from each hernia summed up) results in a total of 706.99 DALYs.

According to Fox-Rushby and Hanson,[25] we analyzed the DALYs based on different discounting rates and different age weighting to show possible influences and enable a critical view of our results. The sensitivity analysis suggested by Fox-Rushby and Hanson is presented in Table 2.

The total costs for the mission amounted to $8,485.26, with a total of $19,210.73 if the hospital costs are included (societal perspective). Single-procedure costs amounted to $198.87 per patient, with $39.35 per procedure from a patient perspective.

Most costs were due to the mission team itself (44.17%), whereas fixed costs accounted for 24.46% and intraoperative costs for 26.45% (if spinal anesthesia is included: 30.27%). The postoperative course produced a negligible contribution to the total costs (1.3%). We also analyzed the different forms of anesthesia with regard to costs. Local anesthesia proved to be 6.6% cheaper ($174.39 versus $186.73). The breakdown for cost factors is presented in Table 3.

The incremental CE (ICE) analysis was based on the 619.05 DALYs averted. We spent $31.04/DALY from a societal perspective, $13.71/DALY from a provider perspective, and $6.81/DALY from a patient perspective. This was well below (around 90 times) the threshold of $2790 [gross domestic product (GDP) per capita].[27] Even after considering all different scenarios (discount rate, solely Nigerian surgeons, inclusion of Swiss salaries), the interventions presented still remained cost-effective.

Subsequently we analyzed the CE from a provider and societal perspective concerning the origin of the surgeon. If analyzed separately, Nigerian surgeons amounted to 65.96 DALYs per dollar concerning the ICE, and Swiss surgeons to 58.8 DALYs per dollar. All of the different scenarios are presented in Table 4.

Discussion

Inguinal hernia repair in a district hospital proved to be highly cost-effective during a short medical mission trip to rural Nigeria. It is absolutely essential to generate further funding for such surgical missions, especially because these teaching missions aim to improve the local surgical capacity.

We aimed to present a CEA, comparing our results to other published data. We averted a total of 619.05 DALYs, with overall costs of $19,210.73 accounting for $31.04/DALY averted. This seems to be well in the range of published data on DALYs averted at a district hospital level in Africa, which is thought to be between $19 and $102.[28]

Results concerning the CE of MSTs providing surgical care for inguinal hernias are sparse. To our knowledge Shillcutt *et al*[2,3] contributed the first publications in 2010 and 2013, showing ICE between $12.88 (Shillcutt *et al*[2]) and $78.18 (Shillcutt *et al*[3]) per DALY averted. One additional trial from Löfgren *et al*,[6] comparing MNM and commercial meshes, presented a range from $16.8 (MNM) to $58.2

Table 3 Cost analysis distributed for patient/provider costs

	Total amount in $[a]	Average amount per patient	Percentage of total amount
Provider perspective costs			
Mission team[b]			
Flights	5408.11	50.54	28.15
Journey	698.98	6.53	3.64
Visa	438.46	4.10	2.28
Supplies	1042.79	9.75	5.43
Accommodation	695.19	6.50	3.62
Tax fee	201.73	1.89	1.05
Subtotal	**8485.26**	**79.30**	**44.17**
Fixed costs			
Renting fee (furnished)[c]	3161.53	29.55	16.46
Overhead/maintenance[d]	1036.08	9.68	5.39
Salary[e]	463.48	4.33	2.41
Subtotal	**4661.09**	**43.56**	**24.26**
Intraoperative costs (surgery)			
Disposable[f]	1891.93	17.68	9.85
Nondisposable[g]	656.13	6.13	3.42
Local anesthesia[h]	934.89	12.14	4.87
Medication[i]	450.23	4.21	2.34
MNM	1.23	0.01	0
Salary[j]	1146.46	6.55	5.97
Subtotal	**5080.87**	**46.72**	**26.45**
Volume-driven costs (anesthesia)			
Medication	220.80	7.36	1.15
Disposable	282.00	9.40	1.47
Salary	231.73	7.72	1.21
Subtotal	**734.53**	**24.48**	**3.82**
Postoperative costs			
Disposable[k]	17.25	0.58	0.09
Salary[l]	231.73	4.23	1.21
Subtotal	**248.98**	**4.81**	**1.3**
Total provider costs	**19,210.73**	**198.87**	**100**
Patient perspective costs			
Intervention costs			
Surgery fee		31.70	80.56
Laboratory tests		None	None
Patient administration		2.21	5.62
Intervention-seeking costs			
Journey		0.67	1.70
Supplies[m]		3.80	9.66
Postoperative costs			
Supplies[n]		0.97	1.7
Total patient costs		**39.35**	**99.24**[o]

[a]Exchange rate as of May 16, 2017; http://www.finanzen.ch/waehrungsrechner/schweizer-franken-us-dollar.

[b]Comprises fixed costs for 5 team members [1 senior surgeon (team leader); 1 consultant surgeon/anesthesiologist; 1 theater nurse; 1 resident in surgery]. Journey costs comprise all traveling costs in the home country and abroad.

[c]According to Creese, calculated for an operating room (OR) measuring 200 m^2 and a ward measuring 400 m^2.

[d]Electricity (7 AM–10 PM), diesel generator, cleaning materials for OR; extrapolated from Debas *et al*.[8]

[e]Comprises 2 assisting staff members for the OR: 1 janitor and 1 coordinator (local employee).

Table 3 Continued

[f]Dressing, suture, syringes, needles, surgical material (blade, glove, disinfection surgeon/assistant), disinfection operating field.

[g]Gowns and drapes, surgical set, shoes—extrapolated from Debas *et al*.[8]

[h]0.25% ropivacaine, syringe, needle, alcohol, and cotton.

[i]Total 6 g of paracetamol; 1 g of co-amoxiclav.

[j]Comprises 6 assistants and 2 coordinators; 2 assistants paid as physician.

[k]Material for dressing change on first postoperative day.

[l]Comprises 2 ward nurses.

[m]Patients were asked to buy their own water for medication and postoperative rehydration; standard meals and drinks assessed by https://www.numbeo.com/cost-of-living/country_result.jsp?country=Nigeria.

[n]Comprises dinner and breakfast on the day after surgery; patients were asked to bear the costs themselves.

[o]Due to rounding not exactly 100%.

[p]Tax for imported material; arbitrarily calculated by the border control officer in charge.

(commercial mesh) per DALY averted. With the results given from our trial we are well in the range of the previously published data.

The above-mentioned CEAs are representing specific circumstances, and thus, as Grimes *et al* stated, do not allow extrapolation to other countries. Therefore, each mission and each presented trial is crucial for gaining knowledge about CE in the mentioned countries.

We could demonstrate that inguinal hernia repair in such a setting is highly cost-effective. As we consider CE up to the threshold of the GDP per

Table 4 Sensitivity analysis and ICE analysis in different scenarios

	Total cost, $	DALYs averted	ICE, $/DALY
Reference DALY (0.03;0;0.04)			
Provider perspective	8485.26	619.05	13.71
Societal perspective	19,210.73	619.05	31.04
Patient perspective	39.35	5.78	6.81
Solely Nigerian surgeons	19,210.73	292.24	65.74
Solely Swiss surgeons	19,210.73	326.81	58.78
Without pediatric hernia	17,343.43	514.26	33.73
With Swiss salaries	55,265.98	619.05	89.28
Local salaries	18,007.96	619.05	29.09
DALY (0.06;0;0.04)			
Provider perspective	8485.26	398.26	21.31
Societal perspective	19,210.73	398.26	48.24
Patient perspective	39.35	3.72	10.58
DALY (0;1;0.04)			
Provider perspective	8485.26	952.08	8.91
Societal perspective	19,210.73	952.08	20.18
Patient perspective	39.35	8.9	4.42

capita we have shown our mission to be around 90 times lower than the GDP per capita of Nigeria. With the $31.04/DALY averted we are well below results that have been presented from trials performed in orthopedic and trauma care ($343–$362 per DALY averted; Nicaragua), cesarean delivery ($376 per DALY averted), and in the range of male circumcision ($7.38–$319.29 per DALY averted) or cleft lip and palate surgery ($15.44–$96.04 per DALY averted).

Comparable interventions from the nonsurgical sector are well promoted for a variety of medical conditions: HIV therapy and prevention ($3–$5175 per DALY averted), malaria interventions ($9–$96 per DALY averted), breastfeeding promotion ($527–$2001 per DALY averted), bipolar affective disorder ($1587–$4928 per DALY averted), and oral rehydration therapy ($132–$2570 per DALY averted). We do want to emphasize that this is not a question considering either surgical or medical promotion in delivering health but an argument to consider surgical therapy during MSTs as feasible and potentially cost-effective.

Another crucial point presented during this study is that the MSTs carried out in Okpoga remain teaching missions. With $65,74/DALY averted, the Nigerian surgeons contributed significantly to the cost efficiency of this trial. These results will be a threshold during further trials to ensure the independence of local surgeons. This is, to our knowledge, the first trial presenting results investigating the contribution by local surgeons to cost efficiency.

We need to acknowledge the limitations of our study. We used locally available consumables as far as possible. Nevertheless, to prevent straining the limited resources of the hospital most of this material was brought by the mission team. These costs are calculated based on Swiss prices. The price of locally purchased consumables, however, is highly influenced by Nigerian policy and economic status. Thus, the generalizability of our results for other countries is limited.[4]

Furthermore, the equation used to calculate the DALYs averted was described in previous publications[25,26] and is widely used during CEA. However, there is no agreement yet concerning standards in the use of age-weighting and discounting life years among researchers presenting results from surgical MSTs.[4] Because we used the recommendations from the WHO-Choice[21] and the initial Global Burden of Disease Study we acknowledge that these results might differ when using the standards from the most recent Global Burden of Disease Study.[29] Because of recommendations from initial trials[2,25,29] we performed this analysis with the standards presented above and with an additional sensitivity analysis.

We have to acknowledge that the basic analysis of salaries paid to local coworkers in this trial represents the mean salaries given by nongovernmental sources. This could well be overestimated and was therefore adjusted to local Okpoga salaries taken from the payroll of each employee.

In summary, we present the first CEA from rural Nigeria dealing with inguinal hernia repair during an MST. With these results we were able to prove cost-effectiveness and remain about 90 times below the threshold of the GDP per capita. We would like to emphasize that further CEAs from around the world are needed to ensure comparability for future missions. Performing surgical MSTs in rural settings as described above help decrease the burden of surgical disease. They also address the shortage of health workers by repetitive training missions.[20] Further research could increase awareness among funding partners and thus promote the importance of essential and emergency surgery among global health politics.

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