Health Policy and Planning, 33, 2018, 999–1008
doi: 10.1093/heapol/czy078
Advance Access Publication Date: 24 September 2018
Original Article

OXFORD

Estimating the cost and cost-effectiveness for obstetric fistula repair in hospitals in Uganda: a low income country

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Accepted on 13 August 2018

Abstract

In Africa, about 33 000 cases of obstetric fistula occur each year. Women with fistula experience debilitating incontinence of urine and/or faeces and are often socially ostracized. Worldwide, Uganda ranks third among countries with the highest burden of obstetric fistula. Obstetric fistula repair competes for scarce resources with other healthcare interventions in resource-limited settings, even though it is surgically efficacious. There is limited documentation of its cost-effectiveness in the most affected settings. We therefore sought to assess the cost-effectiveness of surgical intervention for obstetric fistula in Uganda so as to provide appropriate data for policy-makers to prioritize fistula repair and reduce women's suffering in similarly burdened countries. We built a decision-analytic model from the perspective of Uganda's National Health System to estimate the cost-effectiveness of vesico-vaginal and recto-vaginal fistula surgery vs a competing strategy of no surgery for Ugandan women with fistula. Long-term disability outcomes were assessed based on a lifetime Markov state-transition cohort and effectiveness of surgery. Surgical costs were estimated by micro-costing local Ugandan health resources. Disability weights associated with vesico-vaginal, recto-vaginal fistula and mortality rates among the general population in Uganda were based on published sources. The cost of providing fistula repair surgery in Uganda was estimated at $378 per procedure. For a hypothetical 20-year-old woman, surgery was estimated to decrease the lifetime disability burden from 8.53 DALYs to 1.51 DALYs, yielding a cost per DALY averted of $54. The results were robust to variations in model inputs in one-way and probabilistic sensitivity analyses. Surgery for obstetric fistula appears highly cost-effective in Uganda. In similar low-income countries, governments and non-governmental organizations need to prioritize training and strengthening surgical capacity to increase access to fistula surgical care, which would be an important step towards achieving universal health coverage.

Keywords: Health policy, cost-effectiveness analysis, maternal morbidity and mortality, obstetric fistula in Uganda, low-income countries, health financing, cost analysis

Key Messages

- The United Nations *2030 agenda for sustainable development* embraces Good health as a precondition for, an outcome and measure of, sustainable development. The drivers of good health are interdependent, and as in obstetric fistula, socio-economic factors, health systems, health infrastructure, personnel and health financing are essential components of Universal Health Coverage that need to be addressed.
- In addition, the third Disease Control Priorities (DCP3) reports that once women develop fistulas, transportation to a medical facility is extremely difficult because of the cost of transportation and also because of the inadequate hygiene and leaking that women with fistulas exhibit. A 2001 United Nations Population Fund (UNFPA) survey of fistula patients in Tanzania reports that some women travel as far as 500 kilometres to reach the nearest fistula centre (UNFPA 2001). The survey notes that of 32 fistula centres, only 3 provide free surgery.
- The prevention of fistula requires significant social and economic attention. Investing in medical facilities that are able to provide adequate prenatal care as well as healthy deliveries needs to be a priority (DCP3). Prenatal care, with early identification of at-risk pregnancies coupled with early referral to delivery centres capable of operative delivery, is essential for prevention. The cost of prenatal care varies by country, as well as by government-provided insurance plan, but all costs for these preventive strategies are significantly lower than the cost of later treatment (DCP3).
- Achieving the 2030 agenda of sustainable development worldwide will require significant advances in Maternal and Child Health. This will entail a global strategy towards strengthening of the health systems to provide this cost-effective fistula surgery, and address the gaps leading to prolonged obstructed labour in low- and middle-income countries. Our study provides data on the cost and cost-effectiveness of obstetric fistula repair from Uganda, a low-income country in Sub-Saharan Africa. Here, we provide data that might convince policy-makers to prioritize this type of surgery and therefore reduce the burden of fistula.
- This is the first publication on cost-effectiveness of obstetric fistula repair in the region; where we estimated the cost and cost-effectiveness of surgical repair for obstetric fistula. Our model found obstetric fistula surgical repair to be the optimal strategy for management of this condition. Surgery for obstetric fistula is highly cost-effective in Uganda. Our finding is consistent with a previous modelled analysis of surgically avertable obstetric conditions in lower- and middle-income countries. Increasing access to quality and highly effective obstetric and fistula surgery could improve health outcomes for many affected women in resource-limited settings. Our study therefore provides data for policy makers to prioritize implementation of this highly cost-effective procedure in developing countries. This will be a great step towards achieving the World Health Assembly resolution on 'Strengthening emergency and essential surgical care and anaesthesia as a component of Universal Health Coverage'.

Introduction

Globally, every day, an estimated 830 women die from complications arising during pregnancy or childbirth; with 99% of deaths occurring in developing countries. However, for every maternal death, 30–50% of women who survive suffer disabling or humiliating injuries including obstetric fistula (World Health Organization, 2015; You *et al*., 2015). In Sub-Saharan Africa alone, 33 000 new cases of obstetric fistula occur annually (UNFPA, 2005) driven by prolonged obstructed labour, poverty, inaccessible health services, poor utilization of health services, poor referral systems and low quality of health services, including poorly-managed caesarean sections (Hancock, 2005; UNFPA, 2005; Kelly and Winter, 2007; Barageine *et al*., 2014). In Uganda, the burden of obstetric fistula remains unacceptably high at 2% of women of reproductive age, 15–49 years (UBOS, 2012). Obstetric fistula may be found in older women, often having lived for decades with this condition. Currently, an estimated 200 000 Ugandan women have obstetric fistula with up to 1900 new cases occurring each year (MOH, 2011).

Usually, obstetric fistula is a complication of prolonged obstructed labour, caused by cephalo-pelvic disproportion and poor obstetric care. Specifically, obstetric fistula results from necrosis of the anterior and sometimes posterior vaginal wall, bladder, urethra and rectum, after prolonged compression of these tissues by the foetal head and the maternal pubis during labour. Between the 4th and 14th day post-partum, after the necrotic tissue sloughs off, incontinence appears. Risk factors for obstetric fistula include malnutrition or stunting, repeated infections, large babies (weight 3.5 kg or higher), insufficient access to emergency obstetric care, preference delivery at home with Traditional Birth Attendants, short stature (<150 cm tall) and poorly managed caesarean sections at health facilities (Tebeu *et al*., 2012; Barageine *et al*., 2014). Adolescents are at increased risk for obstetric fistula due to physical immaturity and a less developed pelvis (Tebeu *et al*., 2012).

Obstetric fistula occurs almost exclusively in women living in low-income settings. The social impact of urinary incontinence is isolation, social deprivation and inability to engage in household chores and productive socioeconomic activities to support their families (Barageine *et al*., 2015; Mselle and Kohi, 2015). Compounding economic losses, incontinence leads to soiling of personal effects and generates odours that strain interpersonal relationships and obstetric fistula has been shown to significantly reduce quality of life (Barageine *et al*., 2015). Medical and gynaecological complications may include acquisition of infections, depression and anxiety (Hilton and Ward, 1998; Browning *et al*., 2007; Holme *et al*., 2007). Obstetric fistula results in a high burden of disease (as measured in disability adjusted life years or DALYs) because the condition occurs in young women. Surgical repair of obstetric fistula is often complex and may require long hospital stays, exacting a toll on the health system (Barageine *et al*., 2015; Mselle and Kohi, 2015).

Obstetric fistula is prevented by access to skilled care during delivery, closely monitoring progress during labour, and by providing

timely caesarean sections when indicated (Higashi *et al*., 2015). However, low- and middle-income countries lack sufficient surgeons and resources to treat patients with obstetric fistula. The current total capacity for fistula repair in Sub-Saharan Africa is estimated to be around 10 000 women per year (Vangeenderhuysen *et al*., 2001) but 2 000 000–4 000 000 African women are estimated to have an unrepaired vesico-vaginal fistula (Vangeenderhuysen *et al*., 2001; Wall, 2006).

While the current estimates of unmet need for fistula surgical repair in low-income countries are not well documented, it was estimated to be as high as 99% in 2008 (Ahmed *et al*., 2007), and the morbidity and mortality posed by obstructed labour remains unacceptably high in contrast to the numbers seen in the high-income countries (Lozano *et al*., 2012; Adler *et al*., 2013).

Obstetric fistula may be managed conservatively using a Foley's catheter or surgically for complicated or longstanding fistulas (Waaldijk, 2004). The Foley's urethral catheter (which is used for fresh small genital fistulas, <2 cm) permits continuous bladder drainage promotes healing of the fistula by preventing distension of the urinary bladder (Waaldijk, 2004; Arrowsmith *et al*., 2010). When Foley's catheters fail, or when fistulae fail to close, surgical repair is the recommended treatment. Following surgical repair, patients remain in hospital for 14 days for strict catheter care (Creanga Andrerea *et al*., 2008; FIGO and UNFPA, 2011). The success rate for surgical repair can exceed 92% if the surgeon has the requisite expertise and the fistula is not a recurrence (Waaldijk, 1995; Raassen *et al*., 2008; Brian and Browning, 2009; Hancock, 2009; Kayondo *et al*., 2011).

In Uganda, patients undergoing fistula surgery are treated following WHO guidelines and national policies are available (Lewis and De Bernis, 2006; MOH, 2011). However, there is limited access to fistula care because few surgeons in the country are able to carry out fistula repairs and care is often delivered via periodic surgical camps organized by local and expatriate surgeons (MOH, 2007; 2011). The United Nations Population Fund estimated that a fistula surgical repair would cost $75–120 at a Ugandan hospital in Kamuli, but how this calculation was made was not explained and this figure is likely outdated (UNFPA and MOH, 2004). To date, the cost and effectiveness of fistula repair in low-income settings like Uganda has not been systematically evaluated.

Here, findings are presented from a simulation model of the cost-effectiveness of obstetric fistula repair at Mulago, a centre of excellence for fistula repair in Uganda. Results of this analysis could assist policy-makers in determining whether surgical repair of fistula should be prioritized. These results could guide budgetary decisions about whether to invest additional resources into the training of healthcare personnel to prevent, identify and treat obstetric fistula in Uganda and other low-income settings.

Methods

The study was conducted in two phases. In the first phase, the average cost of vesico-vaginal and recto-vaginal fistula repair from the provider's perspective was estimated in the target population. Consistent with published methodological recommendations (Hendriks *et al*., 2014), this cost analysis utilized a bottom-up micro-costing approach, where healthcare resources necessary for performing fistula surgery were identified through expert interviews. Thereafter, each resource was assigned a cost on the basis of publicly available local price lists. The average cost of fistula surgery was defined as the sum of all individual cost components. The study excluded overhead costs not directly related to the surgical procedure, including those associated with the hospital building or general healthcare infrastructure, and indirect costs such as travel time or work loss for the individual patient as a consequence of the surgery.

In the second phase, a decision-analytic model was developed to estimate the cost-effectiveness of fistula surgery in a cohort of Ugandan women at an average age of 20 years from the perspective of the national health system (Figure 1). The model compared a strategy of fistula surgery to a strategy of no surgery. Long-term disability outcomes were evaluated using a lifetime Markov state-transition cohort with annual cycle length. The effectiveness of surgery, disability weight associated with vesico-vaginal fistula and mortality rate among women in the general population in Uganda were obtained from published sources (Salomon *et al*., 2012). The cost of fistula repair surgery was estimated from the first phase of the project. All future costs and benefits were discounted at 3% per year. Calculations were performed using TreeAge Pro 2017 (Treeage Software, Inc., Williamstown, MA, USA)

Settings

The analysis was conducted at the Centre for Fistula Care in Mulago National Referral Hospital in Kampala (Mulago) and at Kitovu Regional Referral Hospital in Kitovu, Uganda. Surgeons at Mulago perform approximately 240–360 surgical fistula repairs per year, as compared with about 1000 repairs per year performed at Kitovu. In one-on-one interviews, urogenital gynaecologists who perform fistula repair surgeries and supporting nurses provided information on the average time and human resources required for a typical surgery. Respondents were asked to list all other healthcare resources (surgical instruments, pharmaceuticals and number of hospital days for recuperation) that are generally associated with fistula repair surgery. (Tables 1–3; Cost inputs for fistula surgery: To obtain the total costs of the Fistula repair the costs of the personnel and laboratory investigations (Table 1), anaesthesia supplies and equipment (Table 2) and surgery supplies and equipment (Table 3). The average cost per surgery on combining all the cost estimations, including 28 day admission costs for the patient was $378.04 USD.) Monthly salary data were self-reported by the individual respondents and converted to an average cost per surgery, assuming that the surgeons and support staff would participate in 24 surgeries per month. The cost per hospital day was assessed through interviews with hospital administrators. The costs of pharmaceuticals, surgical equipment and other healthcare resources associated with pre- and post-surgery care were obtained from the Ugandan Joint Medical Stores catalogue of November 2016 (JMS Uganda, 2016). Local currency was converted at an exchange rate of 3400 Ugandan Shillings per 1 US dollar (2016).

Model inputs

Baseline proportions of 78.8% for vesico-vaginal fistula and 21.2% for recto-vaginal fistula were obtained from an Ethiopian study of 716 women presenting for fistula surgery (Kelly, 1992). In that cohort, both fistula types were observed to co-occur in 16.9% of cases, but the model made the simplifying assumption that co-occurring vesico-vaginal and recto-vaginal fistula could be repaired in a single surgery. Without surgical intervention, it was assumed that the presence of fistula would carry a disability weight of 0.338 for vesico-vaginal and 0.492 for recto-vaginal fistula, and that this disability would persist over the remaining lifetime of the patient (Salomon *et al*., 2012). When both fistula types co-occurred, the higher disability weight was assumed. Obstetric fistula was not assumed to increase

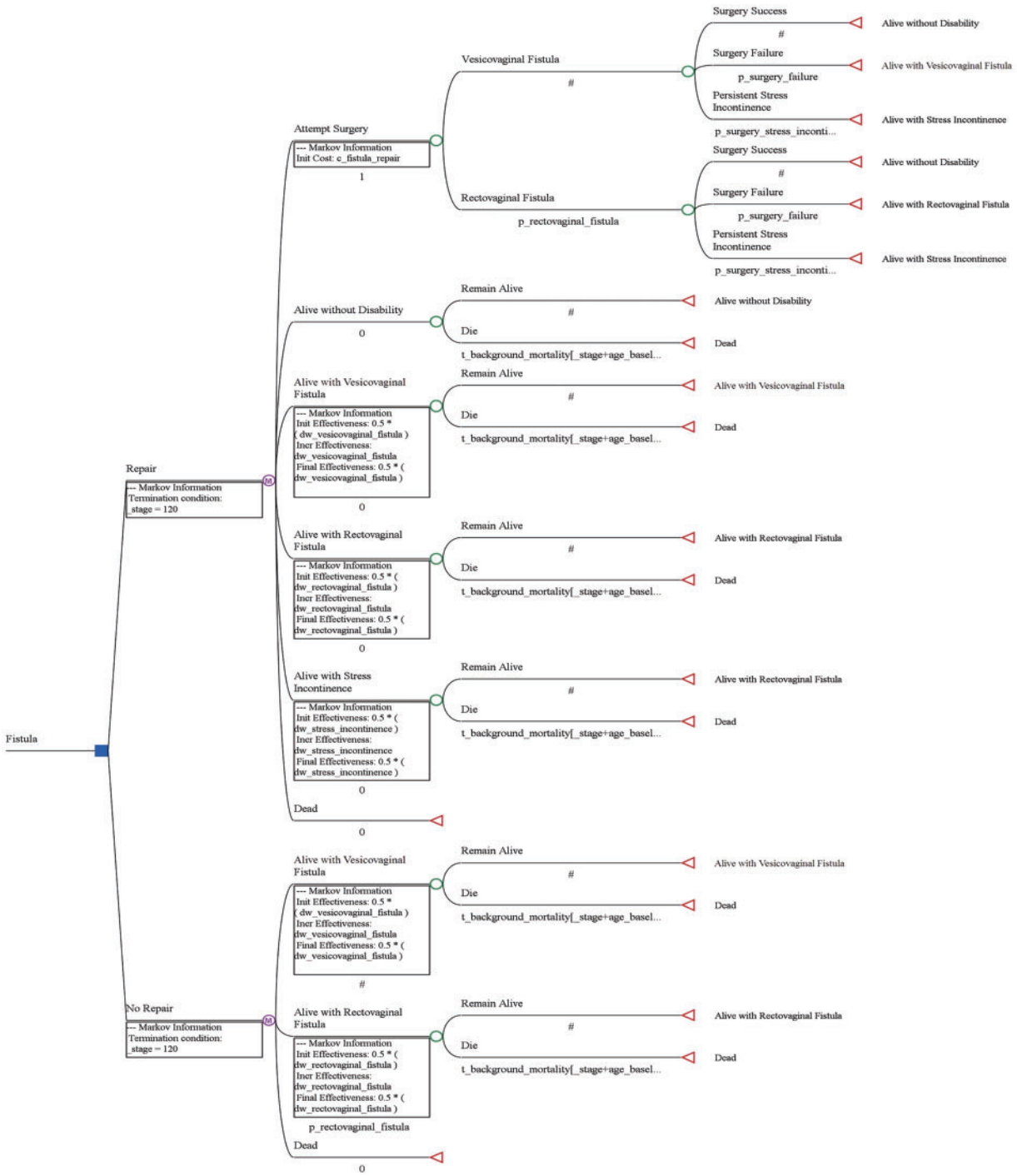

Figure 1. Model structure.

the risk of mortality in the control arm; that is, the burden of disease was driven entirely by the impact of disability.

Similarly, expected surgical outcomes in the intervention arm were informed by results of the Ethiopian study, where successful fistula repair was accomplished in 84.6% of patients, surgery failed in 6.3% and an outcome of stress incontinence persisted in 9.1% (Kelly, 1992). For a successful surgical outcome, a disability weight of zero was applied in the model. Persistent stress incontinence carried a disability weight of 0.142 (Salomon *et al.*, 2012). Unsuccessful fistula repair was associated with disability weights matching those of patients in the control arm of the model. The possibility of repeat surgery in unsuccessful cases was excluded from the model. Annual mortality rate of Ugandan women in the general population was obtained from publicly available life tables (WHO, 2011a). In accordance with good modelling practices, all future costs and disability weights were discounted at 3% per year (WHO, 2011b).

Sensitivity analyses

One-way sensitivity analyses were conducted to inform the robustness of the model results to changes in individual parameters. In

Table 1. The cost personnel and laboratory investigations

Item	Details	Cost in USD	Number of surgeries per month	Cost per surgery in USD	Useful life/unit size
A. Personnel[a]					
Anaesthesiologist	01	529.41	40	13.24	Monthly salary: 529.41
Nurse	01	205.88	24	4.90	Monthly salary: 205.88
Senior house officer	01	205.88	100	2.51	Monthly salary: 205.88
Urogynaecological surgeon	01	529.41	24	22.06	Monthly salary: 529.41
B. Lab investigations	CBC (HB)	4.41		4.41	
C. Patient accommodation	28 days (14 days before and after repair)	82.35		82.35	28 days

[a]Personnel salaries as per Ministry of Health Uganda Structure.

Table 2. The costs for the anaesthesia supplies and equipment

Item	Details	Cost in USD	Number of surgeries per month	Cost per surgery in USD	Useful life/unit size
Anaesthesia supplies					
Anaesthesia machine	Anaesthesia machine	25 000.00		17.36	5 years if well serviced
Suction machine	Suction machine	779.41		1.35	2 years if well serviced
Anaesthesia machine exhaust chamber maintenance and gauges for oxygen replacement		132.35		0.46	Once a year
Suction machine maintenance: replacing white filters		10.294		0.86	Every 2 weeks
Spinal needles	Spinal needles (orange gauge 22, black) (1 or 2)	5.88		5.88	Single use per surgery
90% of the time spinal anaesthesia	Bupivacaine (1 bottle) (0.5% 20 ml vial)	3.71		3.34	Single use per surgery
10% of cases general anaesthesia	Isoflurane (1 bottle)	42.35		4.23	
	Ketamine (1 bottle)	1.04		1.04	
	Endo tracheal tubes 6.5/7.0	0.82		0.82	
	Laryngoscope	119		0.08	5 years
	Suction catheters	0.22		0.22	Single use per surgery
IV Fluids—normal saline	Normal saline (6 in number)	2.52		2.52	Single use per surgery
	Cannula gauge 16/18 (2 of them)	2.54		2.54	Single use per surgery
	Giving sets (2 o them)	10.75		10.75	
Monitors	BP, O2, pulse rate monitor	882.35	24	0.61	Lifetime of the machine is 5 years
Surgeons cocktail	Adrenaline	4.41		4.41	Single use per surgery
	Lignocaine (2%), 20 ml vial	8.55		8.55	Single use per surgery
Antibiotics		–		–	
1. 160 mg gentamycin IV	Once	2.35		2.35	Single use per surgery
2. 1G IV ceftriaxone	Once	5.88		5.88	Always used
Analgesics		–		–	
1. Pethidine 50 mg (IM)	3 doses	5.20		5.20	
2. Diclofenac I/V I/M 75 mg (25 mg/ml 3 ml ampoule)	3 doses	14.34		14.34	
3.Tramadol 100 mg (iv)	3 doses	3.74		3.74	May or may not be used

addition, a probabilistic sensitivity analysis was conducted, in which model parameters were randomly drawn from a pre-specified distribution to generate the incremental cost-effectiveness ratio (ICER). This process was repeated 10 000 times, thereby creating a probabilistic ICER distribution. The upper and lower bounds of our model inputs as well as the corresponding distributional assumptions are displayed in Table 4.

Cost inputs for fistula surgery

In order to obtain the total costs of the Fistula repair the costs of the personnel and laboratory investigations (Table 1A), anaesthesia supplies and equipment (Table 1B), and surgery supplies and equipment (Table 1C) The total cost per surgery on combining all the cost estimations, including 28 day admission costs for the patient was 382.84 USD.

Table 3. The inputs for the costs of the Surgery supplies and equipment

Item	Details	Cost in USD	Number of surgeries per month	Cost per surgery in USD	Useful life/unit size
Surgery supplies and equipment					
Gloves		–		–	
– Sterile gloves size 7, 7.5	1 box	12.35		1.5	Each box has 50 pairs. Considering 6 pairs of gloves used per surgery.
– Un-sterile box	1 box	0.43		0.01	
– Heavy duty gloves for cleaning	1 pair ×5	73.55		1.02	3 months
– Jik (cleaning)	1 bottle	4.41		4.41	Single use per surgery
– Soap (cleaning)	1 litre	13.24		13.24	
Sutures		–		–	
Vycril 2.0	1	0.74		0.74	Single use per surgery
Vycril 3.0	2	0.74		0.74	Single use per surgery
Vycril 1.0	1	1.91		1.91	Single use per surgery
Linen 1/0	1	1.91		1.91	Single use per surgery
PDS suture	1	1.03		1.03	Single use per surgery
Nylon	1	1.47		1.47	Single use per surgery
Urinary catheters		–		–	
1. Urethral catheter size 14/16	One catheter	8.40		8.40	Single use per surgery
2. Ureteric catheter		29.41		0.03	3 years
3. Dye test	Bottle of the dye	8.82		8.82	Single use per surgery
Linen in theatre		–		–	
1. Towels (covers instrument trolley, patients bed)	1 metre	10.94		10.94	3 months
2. Abdominal sheets	1 metre	10.94		10.94	3 months
3. Legging clothes (covers the thighs)	1 metre	10.94		10.94	3 months
4. Theatre scrubs	2 pieces	15.28		0.64	Assumes that a pair of scrubs will be used for 24 surgeries
Skin preps	Antiseptic povidone	6.50		6.50	Single use per surgery
Plaster	Plaster (medium roll)	7.73		0.77	It can be used for up to 10 patients
Others	Cotton	4.41		0.88	
	Syringes 2, 5, 10 ml	0.44		1.76	Use up to 4 needles
	Gauze	9.07		9.07	
	Surgical blade	5.51		5.51	
Masks	6 pieces (disposable)	13.25		13.25	Single use per surgery
Gowns (cotton large reusable)	2 pieces	17.29		17.29	3 months
Head caps (cotton reusable)	4 pieces	2.12		2.12	3 months
Re-usable surgical set for VVF repair		–		–	
	Auvard	55.62		0.10	Wears out after 2 years
	Needle holders	10.09		0.02	Wears out after 2 years
	Scissors	6.46		0.01	Wears out after 2 years
	Tissue forceps	5.80		0.01	Wears out after 2 years
	Sponge holding forceps	9.60		0.02	Wears out after 2 years
	Artery forceps	6.70		0.01	Wears out after 2 years
	Sims speculum	5.21		0.01	Wears out after 2 years
	Receiver	6.47		0.01	Wears out after 2 years
	Uterine sound	5.14		0.01	Wears out after 2 years
	Metallic catheter	84.28		0.15	Wears out after 2 years
	Probe	1.37		0.002	Wears out after 2 years
	Varicellum	5.15		0.01	Wears out after 2 years
	Dissecting forceps (toothed)	6.18		0.01	Wears out after 2 years
	Dissecting forceps (non toothed)	3.36		0.01	Wears out after 2 years
	Towel clips	5.35		0.01	Wears out after 2 years
	Bakock	30.25		0.05	Wears out after 2 years
	Two gallipots	6.47		0.01	2 years
Sterilizer		830		0.57	5 years if well serviced
Sterilizer maintenance (valves, gaskets, relays)		161.76		0.37	Replaced 1.5 years
Monthly cleaning of air exhaust tube Small diameter wire 6 months	Done once every month for 30–40 min	20.59		0.86	

(continued)

Table 3. (continued)

Item	Details	Cost in USD	Number of surgeries per month	Cost per surgery in USD	Useful life/unit size
Bi-weekly cleaning of control valve acetone 1 month	Done every 2 weeks for 20 min	147.06		12.26	Twice a month
Water buckets	__3 buckets	13.24		13.24	
Water 80 L required per day	Cleaning the theatre	0.29		0.29	
Heavy duty gloves 5 required 3 months (for cleaning the theatre)	One pair	5.88		5.88	3 months

Table 4. Model inputs

	Mean	Lower limit	Upper limit	Distribution	Reference
Age at baseline, in years	20	16	24	Normal	[10]
Probability of recto-vaginal fistula	0.212	0.143	0.304	Beta	[18]
Probability of vesico-vaginal fistula	0.788	0.696	0.857	N/A	[18]
Disability weight, recto-vaginal fistula	0.492	0.328	0.667	Beta	[19]
Disability weight, vesico-vaginal fistula	0.338	0.232	0.462	Beta	[19]
Disability weight, stress incontinence	0.142	0.089	0.209	Beta	[19]
Cost of surgery, in USD	378.04	339.16	418.65	Normal	Own analysis
Probability of surgical success	0.846	0.778	0.899	N/A	[18]
Probability of surgical failure	0.063	0.044	0.083	Beta	[18]
Probability of persistent incontinence	0.091	0.057	0.139	Beta	[18]
Discount rate	0.03	0.00	0.06	Beta	[21]

N/A, Not applicable.

Results

The costs of healthcare resources required for fistula repair are summarized in Tables 1–3. The average cost of fistula repair is estimated at $378.04. The results of our cost-effectiveness analysis are displayed in Table 5. Since 20 is the average age of fistula occurrence among Ugandan women (Barageine *et al*., 2014; 2015) over the course of her life with fistula in the absence of surgery, the model estimates that she would accrue approximately 8.53 DALYs. According to our model, fistula surgery would reduce that disability burden from 8.53 DALYs to 1.51 DALYs. Fistula surgery does not completely eliminate the DALY burden, because surgery is associated with some probability of surgical failure as well as persistent stress incontinence. Nevertheless, surgery is expected to reduce the disability burden by 7.02 DALYs at a cost of $378.04, yielding an ICER of $54. From our model, surgery costs of up to $4500 would still be cost-effective in this setting.

Results from our one-way sensitivity analysis are displayed in the tornado diagram in Figure 2, which indicates that the results are robust even with major variations in model inputs. The model is most sensitive to variation of the discount rate and the disability weight associated with vesico-vaginal fistula. However, even when varying these two most sensitive parameters, the cost per DALY averted still falls well below relevant cost-effectiveness thresholds. Furthermore, probabilistic sensitivity analysis suggests that 95% of model iterations fell within an ICER range of $40–$79, and 100% of the iterations fall below the per capita GDP threshold in Uganda of approximately $620 (see Figure 3).

Table 5. Base case model results

	Fistula repair surgery	No fistula repair surgery	Difference
Cost per patient	$378.04	$0	$378.04
Lifetime DALYs per patient	1.51	8.53	7.02
Cost per DALY averted			$54

Discussion

Our model's results suggest that surgery reduces the disability due to obstetric fistula at a cost of $54 per DALY averted, an estimate that falls well below the per capita GDP of $620 in Uganda, indicating that fistula repair is highly cost-effective as per WHO cost-effectiveness thresholds (WHO, 2011b). Our finding is an extension of a previously published analysis that estimated the DALY burden of surgically avertable obstetric conditions in lower- and middle-income countries (Higashi *et al*., 2015). We build on this research to show that the obstetric fistula public health burden is not merely avertable, but avertable at a reasonable economic cost. While our finding is limited to the Ugandan setting, it seems likely that it would be broadly applicable to other countries in Africa with a similar economic profile and fistula disease burden.

Notably, Uganda and other low-income countries face competing priorities for their health budget, infectious diseases and non-communicable diseases competing with the provision of maternal and child health services necessary to prevent and treat obstetric fistula. In Uganda, broad health system investments for maternal care have been shown to reduce adverse birth outcomes and increase caesarean section rates by up to 31% (Saving mothers giving life organisation, 2018). Such programmes could contribute to prevention of obstetric fistula, by providing the comprehensive obstetric care

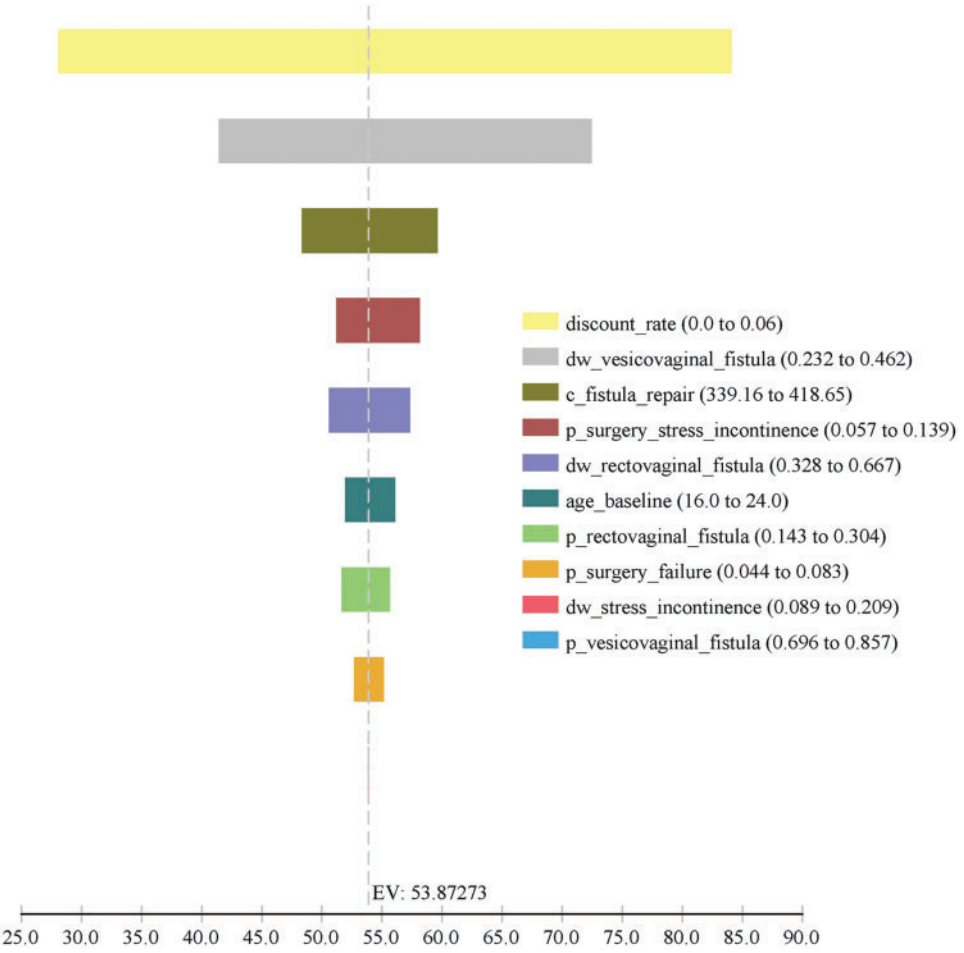

Figure 2. Tornado diagram. Expected Value (EV) of $54 on the x-axis represents the base case cost per DALY averted.
The width of the horizontal bars represents how much the base case estimate varies when a single model parameter is replaced with a low and then a high value from a predetermined range. For example, replacing the base case discount of 3% with a low value of 0% reduces the cost per DALY averted from $54 to $28, whereby increasing the same parameter to 6% increases the cost per DALY averted to $84.

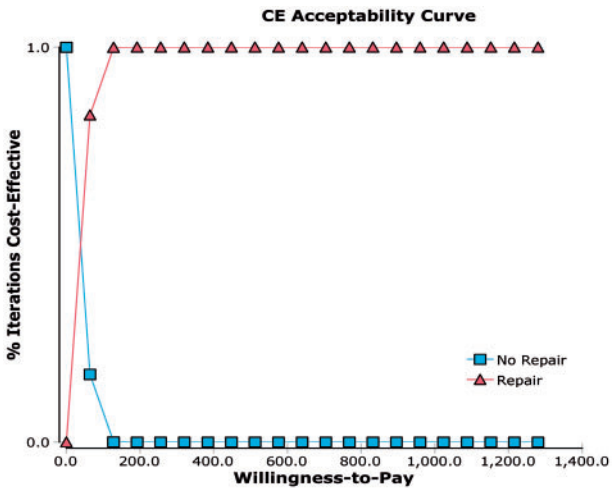

Figure 3. Cost-effectiveness acceptability curve. Willingness to pay refers to the threshold cost per DALY averted at which an intervention is commonly considered to be cost-effective. In this particular case, the threshold is one time per capita GDP in Uganda, e.g. $620. At this threshold, the model results suggest a 100% certainty that OF surgery is cost-effective.

package with timely interventions thus reducing incidences of neglected prolonged obstructed labour. However when obstetric fistula does occur, surgical repair should be provided because of the severe socioeconomic impacts on the women affected. Furthermore, investments in improved gynaecologic surgical care for obstetric fistula will likely benefit other surgical conditions affecting women of reproductive age.

In this study, we assumed that each surgical team would perform 24 surgeries per month or 288 surgeries per year. For 200 000 untreated women, approximately 70 surgical teams will be needed to conduct surgeries for 10 years to cover these women. Currently, 2 specialized centres in Uganda conduct most of these surgeries, assuming 10 teams between these two centres, another 60 surgical teams will need to be established country wide to support scale up for these surgeries. One policy option could be to expand fistula repair surgery to Uganda's 14 regional referral hospitals, where theatre infrastructure is already in place and hire and train surgical teams stationed at regional referral hospitals to implement this approach. While scaling up to cover all untreated women may be daunting, expanding high quality fistula care in line with existing plans for regional referral hospitals with two teams in each of the 14 hospitals, would cost approximately $500 000 in salary costs per

annum and could reach nearly 50% of affected women over the next decade while also strengthening surgical services for maternal health more broadly. While these estimates exclude other costs eg. Training and other hospitalization costs, it does suggest that fistula surgery may still be affordable given that Uganda is proposing an annual budget of 758 billion Uganda shillings (approximately $217 million) for the FY2018/2019 (Uganda Health Sector Budget framework paper, 2018).

To our knowledge, this is the first publication in the region in which the cost and cost-effectiveness of surgical repair for obstetric fistula were estimated. Sub-Saharan Africa is estimated to have the highest proportion of DALYs due to surgical conditions at 38 per 1000 population (Jamison *et al*., 2006). This figure includes injuries, malignancies, congenital anomalies, obstetric complications, cataracts and glaucoma and perinatal conditions. Despite the increasing awareness of the importance of strengthening surgical capacity globally, as reflected in the World Bank's inclusion of surgery in the Disease Control Priorities (Jamison *et al*., 2006), basic surgical care is not a funding priority in many national policies (Farmer and Kim, 2008). However, to achieve the 2030 objective of sustainable development worldwide, significant advances are required in maternal health—both to treat all obstetric fistula patients and to prevent the emergence of new cases. This will entail a global strategy that includes the strengthening of the health systems and surgical workforce to provide this cost-effective fistula surgery, and address the gaps leading to prolonged obstructed labour in low- and middle-income countries.

In addition to the limited availability of facilities that offer fistula repair and the financial costs of the procedure, a 2017 review highlighted other barriers to fistula treatment occurring at individual, community and national levels These include depression, stigma and shame, lack of community-based referral mechanisms, transportation difficulties, gender power imbalances, community reintegration and the competing priorities of political leadership (Bellows *et al*., 2015). While these other barriers were not addressed in the model, we feel that critical priorities for early investment should be in health system strengthening because the relative contributions of the other barriers can only be assessed after facilities and resources to conduct surgical repairs are enhanced.

The *Lancet* commission on surgery reports that 5 billion people worldwide lack access to essential surgery when needed. To address this gap, they recommend scaling up the workforce to 20 surgeons, obstetricians and anaesthetists per 100 000 population by 2030 (Meara *et al*., 2015). This is much higher than the total number of doctors in many low-income countries. While we believe that a grand convergence in maternal and neonatal health is possible by 2030, sustainable solutions for low- and middle-income countries will involve increased investments in health care and support for the training of more medical doctors. From our model, increasing the salaries for the surgical workforce would still be highly cost-effective and would attract more clinicians to participate in this noble service. Our recommendations are in line with the World Bank's third edition of *Disease Control Priorities*, which highlights surgical procedures as cost-effective health care interventions and advocates for their inclusion in promoting universal health coverage (Mock *et al*., 2015).

Limitations

This cost-effective analysis considered the costs of fistula repair at the Mulago and Kitovu Referral Hospital. These hospitals were purposefully selected as they conduct the highest numbers of fistula repairs in the country, but it is not known whether the costs in these settings can be generalized to other healthcare settings in Uganda or other countries in Sub-Saharan Africa with comparable healthcare systems. In addition, this study did not include the capital costs associated with the hospital building or land in the micro-costing methodology, as historical cost records were unavailable. Furthermore, the outcomes associated with fistula repair surgery were based on a published study of patients at Addis Ababa Fistula Hospital in Ethiopia, where patients may have experienced outcomes that differed from those experienced by patients in Uganda. Lastly, the modelling was based on the 2 weeks' post-surgery hospital stay and 3 hours' duration of operation per repair. This may not be the case in some uncomplicated fistulas, which may take <3 h, and more complex ones, which would require >2 weeks post-surgery stay in the hospital. However, during the sensitivity analyses, the results were non-differential upon consideration of time for surgery.

Conclusions

Surgery for obstetric fistula repair appears highly cost-effective in Uganda, suggesting that this intervention constitutes an efficient use of scarce healthcare resources and that a broader use of this intervention would be economically justified. There is need for government, policy-makers and all partners to increase access to surgical care through prioritizing surgical training, increasing salaries and strengthening the infrastructure across the country, which would be an important step towards achieving universal health coverage.

Prevention of obstetric complications could also heighten the cost-effectiveness and feasibility of obstetric fistula surgical repair. We recommend task-sharing to increase capacity for timely caesarean sections by providing training for doctors and midwives to perform emergency caesarean sections and provide safe anaesthesia, thus increasing access to essential surgery in the community. Given that an estimated 15–20% of all pregnancies worldwide require surgical intervention, task-sharing would reduce maternal mortality and morbidity, thereby lowering the costs to society of averting related complications such as obstetric fistula.

Acknowledgements

We are grateful for the support from UCGHI Center for Expertise in Women and SONKE Gender Justice Seed grant towards this cost analysis.

Conflict of interest statement. None declared.

Ethics approval

The School of Medicine Research Ethics Committee Makerere University College of Health Sciences Research and Ethics Committee (SOMREC), REC REF No. 2014-133, approved this study.

Funding

This study was sponsored by the USA National Institutes of Health; (NIH Research Training Grant Number #R25TW009343) during the corresponding author's 2014/2015 Post-doctoral Fellowship in Global Health with UCGHI.

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