An ambulance referral network improves access to emergency obstetric and neonatal care in a district of rural Burundi with high maternal mortality

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Abstract

OBJECTIVES In 2006, Médecins sans Frontières (MSF) established an emergency obstetric and neonatal care (EmONC) referral facility linked to an ambulance referral system for the transfer of women with obstetric complications from peripheral maternity units in Kabezi district, rural Burundi. This study aimed to (i) describe the communication and ambulance service together with the cost; (ii) examine the association between referral times and maternal and early neonatal deaths; and (iii) assess the impact of the referral service on coverage of complicated obstetric cases and caesarean sections.

METHODS Data were collected for the period January to December 2011, using ambulance log books, patient registers and logistics records.

RESULTS In 2011, there were 1478 ambulance call-outs. The median referral time (time from maternity calling for an ambulance to the time the patient arrived at the MSF referral facility) was 78 min (interquartile range, 52–130 min). The total annual cost of the referral system (comprising 1.6 ambulances linked with nine maternity units) was € 85 586 (€ 61/obstetric case transferred or € 0.43/capita/year). Referral times exceeding 3 h were associated with a significantly higher risk of early neonatal deaths (OR, 1.9; 95% CI, 1.1–3.2). MSF coverage of complicated obstetric cases and caesarean sections was estimated to be 80% and 92%, respectively.

CONCLUSION This study demonstrates that it is possible to implement an effective communication and transport system to ensure access to EmONC and also highlights some of the important operational factors to consider, particularly in relation to minimising referral delays.

keywords ambulance, referral, emergency obstetric care, Burundi

Introduction

Maternal mortality ratios remain alarmingly high in much of sub-Saharan Africa. Burundi has one of the highest in the world at 800 deaths/100 000 live births in 2010 (WHO, UNICEF, The World Bank & UN Population Division Maternal Mortality Estimation Interagency Group (MMEIG) 2012) (NB: While lower estimates have been submitted to the MMEIG, these have yet to be validated). Lack of access to emergency obstetric care (EOC) is one of the major factors contributing to this mortality.

In 2006, Médecins sans Frontières (MSF) – an international Non-Governmental Organisation (NGO) – began working in a rural province in Burundi, with the aim of reducing maternal and neonatal mortality. To tackle the problem of lack of access to emergency obstetric services, MSF set up a central emergency obstetric and neonatal care (EmONC) facility, coupled with a 24-h communication network to facilitate ambulance referrals for the transfer of women with obstetric complications from peripheral maternity units to the EmONC facility. In a recently published study, this combination of interventions was estimated to

reduce maternal mortality by 74% (Tayler-Smith *et al.* 2013).

In many cases, efforts to improve access to EOC focus on establishing a minimum number of EOC facilities, improving quality of care in such facilities, and mobilising communities to encourage women to use these services. But, overcoming transport barriers is a relatively neglected area (Hofman *et al.* 2008). In most sub-Saharan settings, ambulances are available, but often poorly managed, badly maintained and have frequent break downs. Their performance remains largely unevaluated (Somigliana *et al.* 2011). In view of this and the high impact that the MSF intervention had on reducing maternal mortality (Tayler-Smith *et al.* 2013), using routine programme data from a rural district in Burundi, we aimed to (i) describe the MSF communication and ambulance service with the related costs incurred; (ii) examine the association between referral times and maternal and early neonatal deaths; (iii) assess the impact of the referral service on coverage of complicated obstetric cases and caesarean sections.

Methods

Design

This was a cross-sectional study involving a retrospective analysis of routine programme data.

Study setting

The setting was Kabezi, a rural district in Burundi with an estimated population of about 198 000 and 9900 expected deliveries per year (Burundi Ministry of Health 2011). The terrain in Kabezi is mountainous, with altitudes ranging from 800 to 2000 m. Aside from one paved road, the rest of the road system is a connection of dirt roads. Public transport networks only exist along the paved road; other transport networks are private and transport costs are exorbitant.

At the time of the study, Kabezi had one general hospital without a functioning operating theatre, nine health centre maternity units, where care provision was overseen by an Italian NGO, and an MSF-run central EmONC reference centre (CURGO, Centre d'Urgence Gyneco-Obstetric). At the level of the health centre maternity units, obstetric care for all normal uncomplicated deliveries was provided by nursing staff. Women with any obstetric complications (Box 1) were referred to CURGO – the only facility performing caesarean sections and offering comprehensive EmONC (Box 2) in Kabezi.

Specialised neonatal care for sick newborns at CURGO was offered in a separate neonatology unit, run by staff trained in neonatal care. CURGO was staffed by a team of midwives, general practitioners with surgical skills, anaesthetists, laboratory technicians and a specialist in obstetrics and gynaecology.

All the maternity units referred women to CURGO, with the distance from maternity units to CURGO ranging between 1 and 70 km (up to 3 h drive one way to the furthest health centre), and most of the maternity units were located in the hills. Figure 1 shows the location of the maternity units relative to CURGO.

CURGO also covered emergency obstetric referrals from a number of such units in two other neighbouring districts. However, at the time of the study, full coverage in these two districts had not yet been achieved and the study focussed only on Kabezi district.

Box 1: Criteria for ambulance referrals to CURGO of women at risk of or with an obstetric complication, Kabezi district, Burundi

Risk factors for a complicated delivery:

- First pregnancy and aged > 35 years.
- Previous deliveries >5.
- First pregnancy and women's height < 1.5 m.
- Previous uterine intervention for example. caesarean section.
- Excessively high uterus.
- History of difficult delivery.
- History of obstetric fistula.
- General medical pathologies: severe anaemia, malnutrition, asthma, diabetes, cardiovascular or renal pathologies, infections (fever >38 °C for at least 24 h), severe malaria.

Obstetric complications:

- Complications of abortion (spontaneous or induced).
- Malpresentation of the foetus/umbilical cord.
- Bleeding during pregnancy.
- Post-partum haemorrhage.
- Prematurity <37 weeks gestation.
- Intrauterine foetal death with no uterine contractions over the next 48 h.
- Pre-eclampsia/eclampsia.
- Prolonged labour (>12 h).
- Premature rupture of membranes (with no contractions for at least 12 h).
- Postpartum sepsis.
- Ectopic pregnancy.
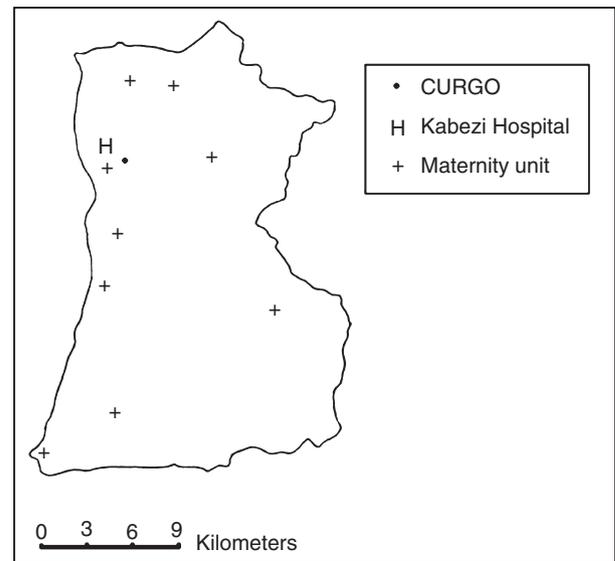
CURGO – Centre d'Urgence Gyneco-Obstetric.

Box 2 Package of comprehensive emergency obstetric and neonatal care offered in CURGO, Kabezi, Burundi

- Administration of antibiotics, oxytocics, anticonvulsants.
- Manual removal of the placenta.
- Removal of retained products following abortion.
- Instrumental vaginal delivery.
- Surgery (caesarean section, hysterectomy, laparotomy).
- Safe blood transfusion.
- Newborn care including care for sick and low birth weight newborns (Essential medicines, blood transfusion, oxygen, basic and advanced resuscitation).

CURGO – Centre d'Urgence Gyneco-Obstetric.

CURGO - Centre d'Urgence Gyneco-Obstetric

Figure 1 Map of Kabezi district showing the location of the peripheral maternity units. CURGO, Centre d'Urgence Gyneco-Obstetric.

Communication and ambulance network. Médecins sans Frontières set up a communication and ambulance network system for the transfer of women referred from peripheral health centre maternity units to CURGO. When a woman at risk of or with an obstetric complication presented at one of the maternity units, the attending nurse contacted CURGO via a two-way radio system [using a solar-powered very high frequency (VHF) system] or cell phone. If specific referral criteria were met (Box 1), an ambulance was sent from the CURGO base to transfer the woman to the CURGO facility. A midwife or nurse trained in the management of deliveries and obstetric complications accompanied the ambulance. Before reaching the maternity unit, any necessary support and guidance about how best to manage the woman, could be provided over the radio to the maternity unit staff by either the ambulance midwife or a midwife based at CURGO. Once the ambulance arrived at the maternity unit, the woman was assessed by the accompanying nurse or midwife, and the obstetric team at CURGO was informed of the tentative diagnosis and management requirements. In some cases, the accompanying nurse or midwife assisted with the delivery at the maternity unit without the need to transfer the women back to CURGO. If the ambulance arrived at the maternity after a mother in question had delivered, the woman was only transferred to CURGO if she still required emergency post-partum care.

Médecins sans Frontières used three ambulances (Toyota Land Cruisers) stationed at CURGO for the transfer of women from maternity units in Kabezi district and the other two neighbouring districts. Based on the proportion of all referrals linked to women resident in Kabezi district (52%), this equates to 1.6 ambulances used for referrals in

Kabezi district. Each of the three ambulances functioned as an independent transfer team, working 24 h a day, every day of the week. The ambulances were well equipped with a radio system, EmONC treatment protocols, a patient stretcher, oxygen and drugs (e.g. tocolytics) that could be administered in the ambulance by the accompanying nurse or midwife en route back to CURGO. The service was offered free of charge.

Study population

This study examined the ambulance call-outs and transfers to CURGO of women at risk of or with obstetric complications, residing in Kabezi district, between January and December 2011.

Data collection and statistical analysis

Data were sourced from the CURGO ambulance call log books, the electronic patient database at CURGO (with records in the database validated by cross-checking registers and patient cards) and MSF's project logistics records. Data variables collected in relation to ambulance call-outs (those calls that led to an ambulance being dispatched from CURGO to a maternity unit) included: the time at which the maternity unit called CURGO, the ambulance departure time from CURGO, the time the ambulance arrived at the maternity unit, whether the call-out resulted in a

patient transfer to CURGO or not and the time when the ambulance arrived back at CURGO with the patient. Data on those women transferred to CURGO comprised age, place of residence, name of referring maternity unit, reason for transfer (morbidity), gestational age, and maternal and neonatal exit outcome. Data on the cost of the communication and ambulance system consisted of the cost of the ambulances (costs calculated based on an estimated 5 years use of the vehicles), medical equipment and drugs on board the ambulances, personnel, fuel, insurance and taxes, vehicle maintenance and radio systems (based on an estimated 10 years use of the equipment). All costs related to the ambulances were based on Kabezi needing 1.6 ambulances as explained above. With no monitoring of when the health centres used cell phones (rather than the radio system) to contact CURGO, cell phone expenses incurred by the health centres were not accounted for. The total cost of the service is therefore reflective of a communications system based solely on radio communication.

The following were reported: total ambulance call-outs, median time between maternity unit calling CURGO and ambulance being dispatched, proportion of call-outs resulting in a patient transfer to CURGO, median referral time (defined as the time from when the maternity unit called CURGO to when the ambulance arrived at CURGO with the patient) and the annual running cost of the communication and ambulance service.

The association between referral time and maternal and early neonatal deaths at CURGO (still births and deaths within 24 h of birth among babies born at CURGO) was also examined and reported using crude odds ratios (OR) with 95% Confidence Intervals (CI). To estimate the impact of MSF's referral system on overall access to EOC in Kabezi district, we calculated the estimated coverage of complicated obstetric cases (assuming that 15% of all pregnant women will have a complication – WHO 2007) and caesarean sections (assuming that a minimum of 5% of deliveries will require a caesarean section – WHO 2012). Complicated obstetric cases were identified in terms of clinical condition (Box 1) or in relation to the requirement for one or more EOC interventions at CURGO (Box 2). Data were analysed using STATA/IC 8.0 software (Stata Corporation, TX, USA).

Results

Ambulance call-outs, patient transfers and cost of the ambulance service

Between January and December 2011, there were 1478 ambulance call-outs. The nature of these call-outs and patient transfers to CURGO is shown in Table 1. The

median time from when the health centre called CURGO to the time when the ambulance was dispatched from CURGO was 30 min (IQR, 15–65 min). Of the 1478 call-outs, 95% (1406) resulted in a patient transfer to CURGO. The median age of these women was 25 years (Interquartile range, 20–30 years) and 27% (383) were pre-term (i.e. <37 weeks gestation): gestational age was unknown for 29% (402) women. The most common reasons for transfer to CURGO were abortions (spontaneous or induced) (21%), history of previous caesarean section (16%) and prolonged/obstructed labour (15%). The median referral time (time from the call-out to the ambulance arriving back at CURGO with the patient) was 78 min (IQR, 52–130 min and maximum 14 h).

The costs of the communication and ambulance service are shown in Table 2. The total annual running cost was € 85 586, which equated to € 61/obstetric case transferred case transferred, or € 0.43/capita/year, when extrapolated to the total population of Kabezi.

Table 1 Ambulance call-outs and reasons for patient transfer to CURGO, Kabezi district, Burundi

Ambulance call-outs and patient transfers	*n* (%)
Total ambulance call-outs	1478*
Median time between maternity unit calling CURGO and ambulance being dispatched†	30 (15–65)
Ambulance call-outs resulting in a patient transfer to CURGO and main reasons	1406 (95)
Abortion (i.e. termination of pregnancy, spontaneous or induced, before 22 weeks gestation)	290 (21)
Previous Caesarean Section	230 (16)
Prolonged (>24 h)/Obstructed labour	216 (15)
Abnormal foetal presentation/umbilical cord	117 (8)
Rupture of membranes >12 h pre-labour	116 (8)
Excessively large fundal height of uterus	91 (6)
Risk of miscarriage (i.e. signs of bleeding, or pain or cramps, or passing of tissue before 22 weeks gestation)	91 (6)
Other‡	255 (18)
Median time from ambulance call-out to arrival at CURGO, minutes (IQR), (*n* = 1320)§	78 (52–130)

CURGO, Centre d'Urgence Gyneco-Obstetric; IQR, interquartile range.
*These call-outs include multiple call-outs for the same women (total number of women = 1385).
†Unknown on 86 occasions.
‡Other includes ante- and post-partum haemorrhage, intrauterine foetal death with no uterine contractions during the next 48 h, pre-eclampsia, uterine rupture, >5 previous deliveries, first pregnancy and women <150 cm in height/small pelvis, previous difficult delivery, first pregnancy and aged >35 years, foetal distress, severe pathologies.
§Unknown on 86 occasions.

Table 2 Cost (in €) of the MSF ambulance and communication system, Kabezi, Burundi, 2011

Costs	Cost per unit	Quantity	Annual costs
Transport			
Vehicles (Toyota Land Cruiser)	31 274	1.6*	10 008†
Stretcher and oxygen on board ambulance	303/ambulance	1.6*	485
Drugs on board ambulances	2262/ambulance	1.6	3619
Vehicle tax and insurance/year	807/ambulance	1.6*	1291
Vehicle repair and maintenance/year	2480/ambulance	1.6*	3968
Fuel/year	7759/ambulance	1.6*	12 414
Drivers – gross salaries	2568/driver	7	17 976
Accompanying nurses – gross salaries	4117/nurse	5	20 585
Communication system			
Radio system at CURGO	2000	1	200‡
Radio operators at CURGO – gross salaries	3183	4	12 732
Radio VHF kits for the health centres	600	9	540§
Solar panel kits for the health centres	1858	9	1672¶
Ambulance radios	600	1.6*	96**
Total	–	–	85 586

CURGO, Centre d'Urgence Gyneco-Obstetric.
*1.6 of three available ambulances for three districts were dedicated to referral activities in Kabezi district alone.
†Cost based on the ambulances having a lifespan of 5 years, equating to € [(31 274 × 1.6 units)/5] per annum.
‡Cost based on the radio kit lasting 10 years, equating to € [2000 × 1 unit/10] per annum.
§Cost based on the radio kits lasting 10 years, equating to € [(600 × 9 units)/10] per annum.
¶Cost based on the solar panel kits lasting 10 years, equating to € [(1858 × 9 units)/10] per annum.
**Cost based on the radio kit lasting 10 years, equating to € [(600 × 1.6 units)/10] per annum.

Table 3 Relationship between referral times and early adverse neonatal outcomes at CURGO, Kabezi

Time from ambulance call-out to arrival at CURGO (hours)	Deliveries at CURGO n (%)	Neonates n (%)	Neonates still born (n-89)/dead <24 h after birth (n-15), n (%)	OR (95% CI)	P-value*
<3	840 (81)	858 (82)	75 (9)	1	
≥ 3	136 (13)	137 (13)	21 (15)	1.9 (1.1–3.2)	0.02
Unknown	57 (6)	57 (5)	8 (14)	–	

CURGO, Centre d'Urgence Gyneco-Obstetric; OR, odds ratio; CI, confidence interval.
*χ^2 test excluding those records for mothers with unknown referral times.

Referral times in relation to maternal and neonatal outcomes

There was one maternal death among the women transferred to CURGO; hence, it was not possible to assess the relationship between referral time and maternal mortality. Among the 1052 neonates born at CURGO, 10% (104) were early neonatal deaths. The two most common causes of neonatal death within the first 24 h of birth (n-15) were asphyxia (53%) followed by congenital malformation (20%). Referral times of 3 h and longer were associated with a significantly higher risk of early neonatal death (121/137 (15%) *vs.* 75/858 (9%) when referral times were <3 h; OR, 1.9; 95% CI, 1.1–3.2), (Table 3).

Maternal age and gestational age (pre-term or full-term pregnancy where this information was known) did not confound this relationship.

A total of 104 neonates were stillborn or died within 24 h of birth. The most common reasons for their mothers' transfers to CURGO were intrauterine foetal death with no uterine contractions over the next 48 h (23%), prolonged/obstructed labour (13%) and abnormal foetal presentation (13%). Of 169 mothers in prolonged/obstructed labour with referral times <3 h, 4% experienced early neonatal deaths, compared to 18% of 34 mothers in prolonged/obstructed labour with referral times >3 h (OR, 5.8; 95% CI, 1.6–20.0; missing data n = 16). For mothers with an abnormal foetal

Table 4 Estimated coverage of complicated obstetric cases and caesarean sections by CURGO and its ambulance referral system in Kabezi District, Burundi

	Catchment population	Expected number	Actual number	Coverage
Complicated obstetric cases	198 000	1485*	1194	80%
Caesarean sections	198 000	475†	437	92%

CURGO, Centre d'Urgence Gyneco-Obstetric.
*Expected number of complicated obstetric cases/year = 15% of all pregnancies. Total number of pregnancies = 5% × population (Burundi Ministry of Health 2011). Thus, expected number of complicated deliveries = 198 000 × 5% × 15% = 1485.
†Minimum expected number of caesareans/year calculated with a 4.8 birth rate (Burundi Ministry of Health 2011) and an acceptable minimum caesarean section rate of 5% using the formula: Population x birth rate
(4.8%) × 5% = 198 000 × 4.8% × 5% = 475.

presentation, 10% (9/86) of neonates suffered an early death when referral times were <3 h *vs.* 36% (4/11) when referral times were ≥ 3 h (OR, 4.9; 95% CI, 1.1–21.0; missing data $n = 6$).

Coverage of complicated obstetric cases and caesarean sections

Médecins sans Frontières coverage of complicated obstetric cases and caesarean sections in Kabezi district was estimated to be 80% and 92%, respectively (Table 4).

Discussion

This study from a rural setting with high maternal mortality shows that an efficient ambulance system facilitates the transfer of women who urgently require emergency obstetric care. Timeliness of transfer was associated with a reduced risk of early neonatal deaths and still births.

One important strength of this study is that an efficient ambulance monitoring system was in place in CURGO, which ensured that ambulance use and timing were systematically recorded, and all running costs documented. As the data were also reviewed and supervised regularly by the logistics and medical departments, we believe they are robust.

The study has several limitations: it was not possible to control for all potential confounding factors when assessing the association between referral times and early neonatal deaths (such as the severity of the mother's condition when arriving at the health centre maternity

unit, comorbidities or possible delays in treatment response at the CURGO facility). Due to reliance on estimates, we may have under or over estimated MSF coverage of complicated obstetric cases and caesarean sections. There was no monitoring of how the communication system functioned at the level of the referring health centres (e.g. how many times the communication system broke down, batteries went flat). While transfer times were most likely directly related to the distance travelled, it was not possible to investigate other factors, such as poor roads, that may also have been associated with longer transfer times, and whether 1.6 centralised ambulances were sufficient to meet the referral demand. Despite these limitations, our findings raise a number of important points for discussion.

Box 3: The main factors that likely underpin the effectiveness of the MSF maternity referral system, Kabezi, Burundi

- An adequately resourced referral facility offering good quality EmONC.
- Robust protocols for the effective identification of obstetric complications, together with health centre staff trained in the proficient use of these protocols.
- A functional and efficient communication system using a two-way solar-powered radio system or cell phones.
- Medically equipped ambulances including a trained midwife or nurse as part of the ambulance team to enhance stabilisation and preparation of women for emergencies interventions.
- Twenty-four hour availability of functional and dedicated ambulances, with independent ambulance teams, providing transport free of charge

CURGO – Centre d'Urgence Gyneco-Obstetric; EmONC, emergency obstetric and neonatal care.

First, timely access to quality EmONC for women with obstetric complications is recognised as being essential for reducing maternal mortality (Paxton *et al.* 2005; Campbell & Graham 2006; WHO 2006a) ensuring that an effective referral system is in place to help achieve this fits within the framework of the Minimal Initial Services Package for reproductive health (Inter-agency Working Group on Reproductive Health in Crises 2010). As only one maternal death was recorded among all of the women transferred to CURGO, it would suggest that MSF's maternity referral system functions in an acceptable manner. The main factors that are likely to underpin

the effectiveness of the MSF maternity referral system are highlighted in Box 3. To be effective overall, each of the components must function well; the maternity care chain is only as strong as its weakest link. These factors are similar to those that have previously been described as being important for ensuring an effective maternity referral system (Murray *et al.* 2001). The importance of ensuring timely access to EmONC through such a referral system is similar to the improvements in survival that have been associated with earlier access to health care for other forms of medical emergencies such as cardiac arrest (Cummins *et al.* 1991). Survival from cardiac arrest is more likely if there is (i) a recognition of early warning signs, (ii) rapid activation of the emergency medical system, (iii) basic cardiopulmonary resuscitation, (iv) availability of defibrillation, (v) intubation and (vi) intravenous administration of medications – a process described by the concept of 'chain of survival'. Similar principles apply to obstetric emergencies and an effective referral system is key for strengthening this 'chain of survival'.

Second, the annual running cost of the MSF communication and ambulance referral system in Kabezi district came to just over € 85 000, which equated to € 61/obstetric case transferred or € 0.43/capita/year (NB: the gross domestic product (GDP) *per capita* in Burundi in 2011 was US$ 271 – approximately € 200, World Bank 2013). In a previous study (Tayler-Smith *et al.* 2013), it was estimated that the MSF intervention in Kabezi (i.e. the EmONC referral facility backed up by a functional patient transfer system) led to a 74% reduction in maternal mortality. In this respect, the annual running cost of the MSF communication and ambulance service would seem well justified, although a better appreciation of the cost-effectiveness of this service would require a more formal analysis which was beyond the scope of this study. A recent study from a remote setting in Uganda has demonstrated that, within the framework of reproductive health, an ambulance service is highly cost-effective (Somigliana *et al.* 2011). That said, alternative initiatives, such as that described from Malawi (Hofman *et al.* 2008), which uses motorcycle ambulances based at the health centres, do have the potential to reduce costs further. The average operating costs of a motorcycle ambulance were over 20 times less than for a car ambulance. A combination of such approaches might be most effective, depending on what is required in terms of distance, geographic terrain and weather conditions. With the growing use and decreasing costs of cell phones in many poor settings, this form of technology may also provide a cheaper and possibly more practical option than VHF radio communication.

Third, while we were not able to examine the association between referral times and maternal deaths (due to so few maternal deaths at CURGO), there is already evidence to indicate that for certain obstetric complications, prognosis is directly related to whether appropriate care is received promptly (for example – within 2 h for post-partum haemorrhage) (WHO 2005). What we did demonstrate was that longer referral times (>3 h) were associated with a higher frequency of early neonatal deaths, particularly in relation to prolonged/obstructed labour and abnormal foetal presentation. This further supports the importance both of keeping referral times to a minimum (Murray *et al.* 2001; WHO 2006b; Fauveau 2007), particularly in the case of prolonged/obstructed labour and abnormal foetal presentation, and factoring them in when delineating an appropriate catchment area for an emergency obstetric referral facility. The median time from the maternity unit calling CURGO to the ambulance being dispatched from CURGO was 30 min. While we would argue that this was acceptable, it draws attention to the need for good coordination between the radio communication room receiving the referral calls and the ambulance teams, in order that time delays during this part of the referral process are kept to a minimum, and ensuring that there are enough ambulances available to meet the referral demand.

Fourth, with the ambulances stationed at the CURGO base, each call-out required an ambulance to travel to the peripheral health centre maternity unit and back again to CURGO. For those maternity units located as far as a 3 h drive away from CURGO, this led to significantly long transfer times. While the ideal might have been to have stationed an ambulance at each of the nine maternity units, this would have required a far greater and unrealistic investment of resources and costs (more ambulances, more ambulance drivers, difficulties with vehicle maintenance, etc.). The initiative reported from Malawi (Hofman *et al.* 2008), which used motorcycle ambulances (consisting of a 250 cc Yamaha motorcycle with sidecar) placed at rural health centres and a car ambulance based at the district hospital, provides a possible solution around this. Not only did this significantly reduce referral times, but motorcycle ambulances were much less likely to be misused for non-health-related purposes than the car ambulances. Another study in Malawi assessed the effectiveness of bicycle ambulances to strengthen an obstetric referral system. However, they found that cultural beliefs deterred pregnant women from using bicycle ambulances (Lungu *et al.* 2001). Thus, some consideration needs to be given to cultural acceptance before an innovative transport intervention is introduced.

Fifth, coverage of complicated obstetric cases and caesarean sections by the MSF referral system was high – an essential requirement if any referral system is to have a maximum impact on maternal outcomes at the population level (Campbell & Graham 2006). This first implies that there is good utilisation of healthcare facilities by women with complicated pregnancies/deliveries in Kabezi, and, secondly, that women with complications are being effectively identified at the level of the health centres. Strategies to increase coverage of complicated deliveries are essential for reducing maternal and neonatal mortality (Fournier *et al.* 2009).

Finally, although not part of the referral and transfer system in place for trying to ensure timely access to EmONC, upon discharge from CURGOMSF offered free transport for women back to the health centre from which they had initially been referred. Knowledge of this service may have positively influenced a woman's decision to agree to be transferred to CURGO, especially when the health centre was far from CURGO.

In conclusion, our findings demonstrate that implementing an effective communication and ambulance system to ensure access to EmONC in a setting with very high maternal mortality, results in acceptable referral coverage of complicated deliveries and caesarean sections. We also highlight some of the important operational factors to consider, particularly in relation to minimising referral delays and reducing costs.

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