Achieving the Millennium Development Goal of reducing maternal mortality in rural Africa: an experience from Burundi

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Abstract

OBJECTIVES To estimate the reduction in maternal mortality associated with the emergency obstetric care provided by Médecins Sans Frontières (MSF) and to compare this to the fifth Millennium Development Goal of reducing maternal mortality.

METHODS The impact of MSF's intervention was approximated by estimating how many deaths were averted among women transferred to and treated at MSF's emergency obstetric care facility in Kabezi, Burundi, with a severe acute maternal morbidity. Using this estimate, the resulting theoretical maternal mortality ratio in Kabezi was calculated and compared to the Millennium Development Goal for Burundi.

RESULTS In 2011, 1385 women from Kabezi were transferred to the MSF facility, of whom 55% had a severe acute maternal morbidity. We estimated that the MSF intervention averted 74% (range 55–99%) of maternal deaths in Kabezi district, equating to a district maternal mortality rate of 208 (range 8–360) deaths/100 000 live births. This lies very near to the 2015 MDG 5 target for Burundi (285 deaths/100 000 live births).

CONCLUSION Provision of quality emergency obstetric care combined with a functional patient transfer system can be associated with a rapid and substantial reduction in maternal mortality, and may thus be a possible way to achieve Millennium Development Goal 5 in rural Africa.

keywords Burundi, maternal mortality, emergency obstetric care, Millennium Development Goal

Introduction

The maternal mortality ratio (MMR) is an important measure of population-level maternal health and is defined as the number of maternal deaths in a given time period per 100 000 live births during the same time period (Ronsmans & Graham 2006). This yardstick is used to assess progress towards achieving the international Millennium Development Goal 5 (MDG 5) of reducing the MMR by 75% between 1990 and 2015 (United Nations General Assembly 2000). Burundi has one of the highest MMRs in the world at 800 deaths/100 000 live births [Maternal Mortality Estimation Interagency Group (MMEIG) 2012], and as in much of sub-Saharan Africa, little progress has been made towards reducing maternal mortality.

In 2006, Médecins Sans Frontières (MSF), an International Non-Governmental Organisation (NGO), began an intervention in a rural province of Burundi with the primary aim to reduce maternal mortality. Two major challenges had to be tackled: lack of adequate referral facilities for emergency obstetric and neonatal care (EmONC), and poor geographic access for women with complicated pregnancies to such services. MSF set up a central EmONC facility together with an emergency patient transfer service from peripheral health centres. Although emergency obstetric care (EOC) reduces maternal deaths (Paxton *et al.* 2005; Campbell & Graham

2006), there is no published literature from African settings that specifically quantifies the population impact of improving availability and access to such care on maternal mortality.

By using data from a rural district in Burundi, we estimated the reduction in maternal mortality associated with the MSF intervention and measured this in relation to the MDG 5 target.

Methods

Design

This study is a retrospective cohort analysis using routine programme data.

Setting and population

The study was conducted in Kabezi, a district in Bujumbura Rural Province of Burundi. The district had an estimated population of 198 000 with 9900 expected deliveries per year (Burundi Ministry of Health 2011). One general hospital without a functioning operating theatre, nine functioning health centre maternities and an MSF-run central EmONC reference centre (CURGO – Centre d'Urgence Gyneco-Obstetric) catered to the obstetric needs of the inhabitants. Apart from CURGO, no other facilities offered comprehensive EmONC in Kabezi. All maternities referred women to CURGO. The distance from maternities to CURGO ranged between 1 and 70 km (up to 3 h drive one way to the furthest health centre).

The study included all women living in Kabezi district who were transferred to CURGO for emergency obstetric complications between January 2011 and December 2011.

Emergency obstetric referral and management at CURGO

When a woman at risk of or with an obstetric complication presented at a peripheral maternity unit, the attending nurse contacted CURGO via radio or telephone. If specific criteria for referral were met (Box 1), an ambulance was sent from the CURGO base to transfer the woman to CURGO. A trained nurse or midwife accompanied the ambulance to the peripheral maternity unit. The woman was assessed there by the accompanying nurse or midwife, and the obstetric team at CURGO was informed of the tentative diagnosis and management requirements. If the ambulance did not reach a peripheral referring maternity until after a mother had delivered, the woman was only transferred to CURGO if she still required emergency post-partum care.

Upon admission to the CURGO centre, a comprehensive package of interventions was offered, including CEmONC (Comprehensive emergency obstetric and newborn care (UNICEF/WHO/UNFPA 1997) – Box 2). The CURGO centre and the patient transfer service operated 24 h a day every day of the week, and all services were offered free of charge.

Box 1: Referral criteria to CURGO for women at risk of or with an obstetric complication, Kabezi district, Burundi

- 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
- Abnormal presentation of baby/umbilical cord
- Bleeding during pregnancy
- Post-partum haemorrhage
- Prematurity <37 weeks gestation
- History of difficult delivery
- History of obstetric fistula
- Baby dead in utero and uterine contractions lasting >48 h
- General medical pathologies: severe anaemia, malnutrition, asthma, diabetes, cardiovascular or renal pathologies, infections (fever >38 °C for at least 24 h), severe malaria
- Pre-eclampsia/eclampsia
- Prolonged labour (>12 h)
- Premature rupture of membranes (with no contractions for at least 12 h)

CURGO – Centre d'Urgence Gyneco-Obstetric.

Box 2: Standard package of Comprehensive Emergency Obstetric and Neonatal care in CURGO

- Antibiotics
- Oxytocin and anticonvulsants (magnesium sulphate)
- Manual removal of the placenta
- Misoprostol and Bakri balloon for treating post-partum haemorrhage
- 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

Maternal deaths, severe acute maternal mortality (SAMM) and death-to-SAMM ratio

A maternal death is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes (WHO 1993). A severe acute maternal morbidity (SAMM) case, also known as a 'near miss' case, is defined as 'a very ill pregnant or recently delivered woman who would have died had it not been that luck and good care were on her side' (Mantel *et al.* 1998; Prual *et al.* 2000; Penney & Brace 2007).

At present, there is no universally accepted case definition of SAMM, although various criteria have been proposed. These criteria are based on organ failure, management (response to disease, e.g. emergency hysterectomy and/or admission into an intensive care unit) and specific diseases (Mantel *et al.* 1998; Waterstone *et al.* 2001; Pattinson & Hall 2003; Say *et al.* 2004; Penney & Brace 2007; Baskett 2008). In the absence of an intensive care unit and/or extensive diagnostic capacity, disease-specific criteria were considered to be the most appropriate for defining SAMM in our setting.

Thus, cases of SAMM were identified if the reason for transfer to or the exit diagnosis from CURGO included any of the following conditions (Box 3): (i) prolonged and/or obstructed labour (>12 h) requiring a caesarean section or instrumental (vacuum assisted) delivery; (ii) complicated abortion (spontaneous or induced); (iii) pre-eclampsia/eclampsia; (iv) ante or post-partum haemorrhage; (v) uterine rupture; (vi) dead baby in utero and uterine contractions lasting >48 h; (vii) sepsis; (viii) severe malaria and (ix) ectopic pregnancy. SAMM was also diagnosed if, in the absence of any of the above conditions, a woman (i) was severely anaemic on admission to CURGO (haemoglobin level <7 g/dl), (ii) required an emergency hysterectomy for any reason or (iii) required a caesarean section due to excessive elevation of the uterus or abnormal presentation of the baby.

The ratio of maternal deaths to cases of SAMM is an indicator of the quality of maternal care; a low ratio indicates a high standard of care.

Box 3: Definitions of some of the conditions identified as a severe acute maternal morbidity (SAMM) at CURGO, Burundi

Pre-eclampsia: Onset of high blood pressure (systolic blood pressure of >140 mmHg or diastolic blood pressure >90 mmHg) and protein in the urine (>300 mg/l or 500 mg in a 24-h sample) with increasing oedema in the extremities and the face, after 20 weeks gestation

Eclampsia: Acute paroxysmal vascular-kidney syndrome, marked by repeated seizures followed by coma during the last months of pregnancy, delivery and, less commonly, post-partum

Ante-partum haemorrhage: Bleeding occurring after 22 weeks gestation, before or during delivery, as a result of one of the following:

a. Placenta praevia: insertion of the placenta at the lower segment of the uterus covering all or part of the opening to the cervix
b. Placental abruption: premature detachment of a normally situated placenta, with formation of an effusion of blood between the placenta and the uterine wall
c. Uterus rupture

Post-partum haemorrhage: >500-ml bleeding from the placental zone, occurring during delivery and in the puerperium period (up to 6 weeks post-delivery). Occurring in relation to the following conditions: retained placenta, uterine inertia, coagulation disorders, soft tissue lesions (vaginal, perineal, cervical)

Sepsis: Puerperal infections that occur in the puerperium period generally with the genital tract as the entry point or more precisely the placental surface, for example, endometritis, pelvic – postoperative peritonitis

Severe malaria: The presence of at least one of these signs/symptoms:

- Seizures or Coma stage II,
- Severe anaemia
- Insufficient renal function
- Hypoglycaemia
- Massive haemoglobinuria
- Vascular collapse and jaundice

CURGO – Centre d'Urgence Gyneco-Obstetric

Box 4: An estimate of the impact of the MSF emergency obstetric care (EOC) intervention on maternal mortality, Kabezi, Burundi

Using data from Mali on maternal deaths and cases of SAMM (Fournier *et al.* 2009), and assuming that they can be extrapolated to Burundi, we estimated that 10.1% (95% confidence interval: 7.5–13.2%) of women with a SAMM would have died in the absence of the MSF intervention. Using this estimate:

(i) Estimated number of SAMM-related maternal deaths averted by the MSF intervention

Expected no. of deaths due to SAMM (A) assuming that there was no MSF intervention

$$= \text{No. of SAMM cases at CURGO} \times 10.1\% \,(\text{range } 7.5 - 13.2)$$

$$A = 765 \times 10.1\% \,(\text{range } 7.5 - 13.2) = 77 \,(\text{range } 57 - 101) \text{ deaths}$$

Expected no. of averted deaths at CURGO (B)

$$= A - (\text{Actual deaths at CURGO + expected no. of SAMM related deaths after discharge from CURGO}^*)$$

$$B = 77 \,(\text{range } 57 - 101) - [1 + (21 \,(\text{range } 16 - 27))] = 55 \,(\text{range } 41 - 73) \text{ deaths}$$

*Data from developing countries (Li *et al.* 1996) indicate the following pattern of maternal deaths in the post-partum period (as a percentage of all maternal deaths): 33% occur >1-day post-partum, 19% beyond 1 week, 11% beyond 2 week and 6% beyond 3 week.

At CURGO, the timing of discharge for SAMM cases discharged $\leq$42 days post-partum/termination of pregnancy (n-761) was as follows: 505 occurred $\geq$1-day & $\leq$1-week post-partum, 171 occurred >1 week, 49 > 2 week, 36 > 3 week' post-partum. Applying the mortality risk of 10.1% (range 7.5–13.2) among SAMM cases → Expected no. of SAMM-related maternal deaths that may have occurred after discharge from CURGO = 10.1% (range
7.5–13.2) × [(33% of 505) + (19% of 171) + (11% × 49) + (6% × 36)] = 21 (range 16–27) deaths

(ii) Estimated contribution of the MSF intervention in reducing the MMR in Kabezi
Based on the national MMR for Burundi (800 deaths/100 000 live births)[a], the total number of expected maternal deaths in Kabezi district (**C**) is calculated as:

$$C = (\text{Burundi MMR} \times \text{live births in Kabezi district})^*/100\,000$$

$$= (800 \times 9306)/100\,000 = 74 \text{ deaths}$$

*Live births = Birth rate[b] × Coverage population = 4.7% × 198 000 = 9306**
**NB. This figure captures all maternal deaths in Kabezi, even those that might occur at home.
Thus, percentage of deaths averted by the MSF intervention (**D**)

$$D = B/C \times 100 = 55 \,(\text{range } 41 - 73)/74 \times 100 = 74\% \,(\text{range } 55 - 99\%)$$

(iii) Estimated MMR in Kabezi district as a result of the MSF intervention

$$= \text{Burundi MMR} - (\text{Burundi MMR} \times D)$$

$$= 800 - [800 \times 74\% \,(\text{range } 55 - 99\%)] = 208 \,(\text{range } 8 - 360) \text{ deaths}/100\,000 \text{ births}$$

(iv) The 2015 MDG 5 for Burundi

Estimated MMR for Burundi in1990[a] = 1100 deaths/100 000 live births
75% reduction of the 1990 MMR = 1100 × 75% = 825 deaths/100 000 live births
2015 MMR for MDG 5 to be reached = 1100 − 825 = 275 deaths/100 000 live births

MSF, Medecins Sans Frontieres; SAMM, severe acute maternal morbidity; CURGO, Centre d'Urgence Gyneco-Obstetric; MMR, maternal mortality ratio; MDG, Millennium Development Goal.
[a]MMEIG 2012.
[b]Burundi Ministry of Health (2011).

Data collection, modelling and statistical analysis

Data were sourced from patient files and registers and entered into an electronic database. The records in the database were validated by cross-checking registers and patient cards. We recorded patient age, residence, name of the referring health centre, reason for transfer to CURGO, date of admission to CURGO, type of delivery, obstetric interventions received, maternal outcome, exit diagnosis and date of exit from CURGO.

The outcomes of interest included (i) number of maternal deaths at CURGO, (ii) number and proportion of SAMM cases and (iii) 'death-to-SAMM ratio'. To estimate how many deaths were potentially averted by the MSF intervention, we compared the number of deaths among women with a SAMM who were beneficiaries of the MSF intervention with the expected number of deaths among the same group of women assuming that the MSF intervention had not existed. The latter was approximated by using existing data from Mali (Fournier *et al.* 2009), which led us to estimate that in the absence of the MSF intervention, 7.5–13.2% of women with a SAMM would have died.

There were four reasons that justified applying this estimate to our setting. The MMR estimate for Mali at the time of Fournier *et al.*'s study [Maternal Mortality Estimation Interagency Group (MMEIG) 2010] was similar to the 2010 MMR estimate for Burundi. The data were from rural Mali, where access to EOC at the time was limited by large geographical distances to health facilities and scarce resources – as in Burundi. The Malian data reflected the situation before implementation of a nationwide maternity referral system, when access to EOC from rural regions was limited. The criteria used to define cases of SAMM in Mali were comparable to those used in our study (Box 3). Based on the estimated number of maternal deaths averted by the MSF intervention, we estimated the associated impact on the MMR in Kabezi (Box 4) and related the latter to the MDG 5 2015 target for Burundi.

Data were analysed using STATA/IC 8.0 software (Stata Corporation, Texas 77845, USA).

Ethical aspects

The study fulfilled the MSF Ethics Review Board-approved criteria for analysis of routinely collected programme data. Similarly, the study was exempted from review by the Burundi Ethics Committee.

Results

Characteristics of the study population

Between January and December 2011, 1385 women from Kabezi were transferred to CURGO with an obstetric complication. Table 1 shows their demographic and obstetric characteristics. Median age was 25 years (interquartile range 20–30 years). The most common reasons for transfer to CURGO were abortions (spontaneous and induced) (21%), history of previous caesarean section (17%) and prolonged/obstructed labour (16%).

Cases of SAMM

Among the 1385 women transferred to CURGO, 765 (55%) were considered to have a SAMM. The most com-

Table 1 Demographic and obstetric characteristics of women from Kabezi district, transferred to CURGO for emergency obstetric complications

Variable	*n* (%)
Total	1385
Age (years)	
13–19	166 (12)
20–29	758 (55)
30–39	374 (27)
40+	72 (5)
Unknown	15 (1)
Median, years (IQR)	25 (20–30)
Type of delivery at CURGO	
Normal	474 (34)
Instrumental	104 (8)
Caesarean section	437 (32)
None*	310 (22)
Delivered at HC/unknown if delivery took place	60 (4)
Reason for transfer	
Prolonged/obstructed labour	216 (16)
Pre- or post-partum haemorrhage	68 (5)
Pre-eclampsia/eclampsia	13 (1)
Uterine rupture	3 (0.2)
Severe pathologies (sepsis/severe anaemia)	12 (1)
Dead baby in utero >48 h	26 (2)
Abortion (spontaneous or induced)	288 (21)
Previous Caesarean Section	229 (17)
Abnormal presentation baby/umbilical cord	117 (8)
Excessive elevation of uterus	90 (6)
Rupture of membranes >12 h pre-labour	116 (8)
Other†	207 (15)

IQR, Interquartile range; CURGO, Centre d'Urgence Gyneco-Obstetric.
*Majority of these (284, 92%) were abortions.
†Other includes risk of miscarriage, >5 previous deliveries, women >150 cm in height, previous difficult delivery, first pregnancy and women >35 years old.

Table 2 Pattern of SAMM among women transferred to CURGO, Kabezi, Burundi

Pattern of SAMM	*n* (%)
Total	765
Prolonged/obstructed labour requiring caesarean section or instrumental delivery	267 (35)
Complicated abortion (spontaneous or induced)	226 (30)
Pre- or post-partum haemorrhage	91 (12)
Caesarean section due to excessively elevated uterus or abnormal presentation of baby requiring caesarean section	73 (10)
Dead baby in utero with uterine contractions >48 h	46 (6)
Pre-eclampsia	18 (2)
Sepsis	15 (2)
Uterine rupture	14 (2)
Ectopic pregnancy	5 (0.7)
Malaria	4 (0.5)
Severe anaemia	4 (0.5)
Emergency hysterectomy	2 (0.3)

SAMM, severe acute maternal morbidity; CURGO, Centre d'Urgence Gyneco-Obstetric.

mon SAMM conditions were prolonged/obstructed labour requiring a caesarean section or instrumental delivery (35%), complicated abortion (30%) and pre- or post-partum haemorrhage (12%) (Table 2).

Impact of the MSF intervention on maternal mortality

There was one death registered at CURGO, and this was due to post-partum sepsis. Based on the number of SAMM cases and number of deaths at CURGO, the death-to-morbidity ratio was 1:765 (i.e. one death to every 765 cases of SAMM). Taking into account that an estimated 21 (range 16–27) SAMM-related deaths may have occurred after discharge from CURGO, we estimated that overall 55 (range 41–73) deaths were averted by the MSF intervention (Box 4). The latter indicates that an estimated 74% (range 55–99%) of deaths in Kabezi district were averted through the MSF intervention, translating into a theoretical MMR of 208 (range 8–360) deaths/100 000 live births in the district. This figure lies very close to the 2015 MDG 5 for Burundi of 285 deaths/100 000 live births (Figure 1).

Discussion

This study from rural sub-Saharan Africa shows that the provision of an EmONC facility combined with a functional patient transfer system was associated with a substantial and rapid reduction in the MMR and may thus be a possible way forward for achieving the MDG 5 of reducing maternal mortality by 2015 in rural Africa.

The study's strengths are a relatively large sample population; well-trained, experienced and supervised staff at CURGO and thus relatively robust clinical data and diagnoses; and careful recording of morbidity and deaths. However, there are also a number of limitations. First, we identified cases of SAMM based predominantly on disease-specific criteria that relied on clinical acumen, which may have influenced the number of SAMM cases. Second, we only had records of maternal deaths that

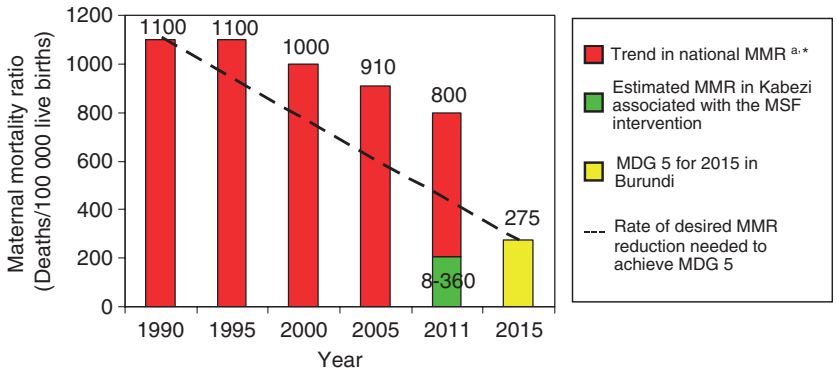

Figure 1 Estimated maternal mortality ratio in Kabezi at the end of 2011 in relation to national trends in MMR and the MDG 5 2015 for Burundi. MSF, Medecins Sans Frontieres; MMR, Maternal Mortality Ratio; MDG, Millennium Development Goal [a]MMEIG 2012. *We acknowledge that other estimates for Burundi's MMR in 2011 have been derived. However, we have opted to use the Maternal Mortality Estimation Inter-Agency Group (MMEIG) estimates in this analysis because (i) the other estimates, although submitted to the MMEIG, have yet to be validated, (ii) MMEIG estimates from 1990 are available (enabling us to track Burundi's progress towards achieving the MDG 5), and (iii) MMEIG estimates are standardised, internationally recognised and comparable.

occurred until women were discharged or transferred from CURGO (rather than up to 42 days post-partum or termination of pregnancy). We did attempt to take account of this by equating in the estimated number of maternal deaths that might have been expected after discharge from CURGO (Box 4). Third, we relied on estimates to measure the overall impact of the MSF intervention on reducing maternal mortality, which may have led to under- or overestimation of this impact. Therefore, 95% confidence intervals were introduced on all estimates. Fourth, the main estimates are derived from data collected in Mali (Fournier *et al.* 2009) and extrapolated to Burundi. While this may be perceived as a limitation, we feel that this approach can be justified as described in the Methods.

Despite these limitations, our results suggest that it is possible to rapidly and substantially reduce maternal mortality in rural Africa. The fact that only one death occurred in CURGO despite the large numbers of SAMM is particularly compelling. Our findings are supported by data from a study in Mali (Fournier *et al.* 2009), which evaluated the effect of a nationwide maternity referral system aimed at reducing maternal deaths related to obstetric complications, by improving access to and the quality of EOC in rural Mali. The referral system relied on three main components: (i) improving communication and transport networks between community health facilities and district health services; (ii) implementing alternative funding options to eliminate financial barriers to obstetric care; and (iii) providing training and equipment to improve the clinical management of obstetric emergencies. Two years after implementation of the intervention, the risk of death among women with obstetric emergencies had halved (odds ratio 0.48, 95% confidence interval 0.30–0.76).

The success of our experience in Burundi is likely underpinned by a number of factors. First, although it is widely accepted that EOC is essential for substantially reducing maternal mortality (Murray *et al.* 2001; Paxton *et al.* 2005; Campbell & Graham 2006), we believe that one of the major factors underlying the success of the MSF intervention was the high standard of care at CURGO. This was reflected by the very low death-to-SAMM ratio (1:765) in comparison with much higher death-to-SAMM ratios of 1:11 to 1:15 in other African hospital settings (Filippi *et al.* 2005). High standards of care were achieved through good infrastructure, available equipment and drugs, sufficient staff capacity, and good management and funding.

Second, the communication and referral transport network allowed EmONC to be readily accessed from peripheral and difficult-to-reach areas. Some of the key factors that seem to have contributed to the success of this referral system were specific protocols for the identification of obstetric complications together with health centre staff proficiency at utilising these protocols – this enabled cases that needed referring to be effectively identified. An effective radio communication system plus round-the-clock availability of ambulances and medically equipped ambulances also contributed to the good result.

Third, coverage of women with obstetric complications by CURGO appeared to be very high. It is generally estimated that about 15% of pregnant women will require EOC (WHO 1994). Thus, with approximately 9900 expected deliveries a year in Kabezi, and 1385 women transferred to CURGO for obstetric complications, this figure was almost achieved. This implies good utilisation of healthcare facilities by women with complicated pregnancies/deliveries and effective identification of women with possible obstetric complications at the health centre level. Both factors are a prerequisite for ensuring rational referrals from health centres that will effectively reduce maternal mortality. In contexts where institutional deliveries are low, strategies to increase this are essential if a maternity referral system is to have the optimum impact on maternal outcomes (Fournier *et al.* 2009). This requires a good understanding of the causes of the first delay in seeking care.

One of the major challenges facing Burundi is the lack of a vital registration system that captures, in a sustained and robust manner, population-level data on maternal mortality and trends. This is a major shortcoming that was not considered during the conception stages of the MDG targets, that is, how does one measure progress towards achieving set targets? This situation needs to be addressed, and possible ways forwards might include introducing village register systems for recording maternal mortality (Graham *et al.* 2008; Zachariah *et al.* 2011).

Overall, the cost of the MSF intervention was approximately two million Euros. Extrapolated to the total population of Kabezi, this amounts to about Euros 3.2/inhabitant/year. Although this is a crude and simplistic estimate, and does not necessarily reflect the specific costs that a Government might need to consider, we present it to give some indication to donors and policy makers of the potential costs and the cost-benefit of this strategy at the population level. A better appreciation of the cost of the intervention would require a formal cost-effectiveness study, which was beyond the scope of this retrospective cohort analysis.

Box 5: Key factors for improving availability and access to quality emergency obstetric care in countries like Burundi (Kongnyuy et al. 2009)

i. *Health policies that are supportive of maternal health* – free maternal health services, free emergency transport and a service package that includes the key components of maternal and newborn health services.
ii. *Infrastructure* – improvements to upgrade facilities so that they can provide EOC, for example, refurbishment of buildings, upgrading of operating theatres, labour and delivery rooms, laboratories, provision of clean water, reliable electricity supply and adequate waste disposal.
iii. *Adequate availability of drugs, supplies and equipment* – vacuum extractors, resuscitation equipment, basic medical instruments, etc., together with management systems to ensure the maintenance and un-ruptured supply of such items.
iv. *Referral system* – including emergency transport and communication for linking health centres with facilities providing EOC on a 24-h basis.
v. *Human resources* – building and strengthening HR planning and management capacity at the level of central government and within a facility, improving supervision, practical skill training and developing staff retention initiatives.
vi. *Health Information Systems* – for monitoring and evaluation of EOC
vii. *Improving healthcare-seeking behaviour* – implementing strategies and initiatives to raise awareness of the danger signs in pregnancy and the importance of seeking urgent medical care when complications present.

HR, human resources; EOC, Emergency Obstetric Care

Finally, although the model of care proposed in this study is fully funded and supported by an NGO, and may thus be subject to questions around replication and sustainability, we do not feel that this should be a major point of discussion. The main message is that if countries like Burundi want to reduce maternal mortality, they need to make maternal health a priority and invest in strategies that ensure that women have timely access to quality EOC. The assumption that improving access to EOC is too costly implies that other equally effective but cheaper solutions exist; but in reality, this is not the case (Maine & Rosenfield 1999). There are no shortcuts around this; it does not matter whether the required funds come from NGOs, Governments or donors – the decisive factor is that investment into such interventions is needed, in a sustained manner. Mali has demonstrated that a national maternity referral system, aimed at improving access to and the quality of EOC, can be implemented on a large scale without major external funding (Fournier *et al.* 2009), and one of the key elements underpinning the success of this programme has clearly been the sustained political support it has received. Other specific elements that would seem key for ensuring access to good quality EOC are good infrastructure, available equipment and drugs, and sufficient staff capacity (Box 5) (Kongnyuy *et al.* 2009). We recognise that the model of care we have proposed may not be entirely replicable, but when investment and resources are limited, these are the essential ingredients that need to be prioritised.

In conclusion, our findings indicate that provision of and access to quality emergency obstetric care through a transport system can substantially and rapidly reduce district-level maternal mortality and may be a way to achieve MDG 5 in Africa.

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References

Baskett T (2008) Epidemiology of obstetric critical care. *Best Pract Res Clin Obstet Gynaecol* **22**, 763–774.

Burundi Ministry of Health (2011). Annuaire Statistiques des donnees des centre de sante et des hopitaux pour l'annee 2010. Ministere de la sante publique et du lutte contre le sida. Direction generale de la sante publique. Service d'Epidémiologie et des Statistiques Sanitaires (EPISTAT).

Campbell O, Graham W & Lancet Maternal Survival Series steering group (2006) Strategies for reducing maternal mortality: getting on with what works. *Lancet* **368**, 1284–1299.

Filippi V, Ronsmans C, Gohou V *et al.* (2005) Maternity wards or emergency obstetric rooms? Incidence of near-miss events in African hospitals *Acta Obstetricia et Gynecologica Scandinavica* **84**, 11–16.

Fournier P, Dumont A, Tourigny C, Dunkley G & Dramé S (2009) Improved access to comprehensive emergency obstetric care and its effect on institutional maternal mortality in rural Mali. *Bulletin of the World Health Organization* **87**, 30–38.

Graham W, Ahmed S, Stanton C, Abou-Zahr C & Campbell O (2008) Measuring maternal mortality: an overview of opportunities and options for developing countries. *BMC Medicine*. **6**, 12.

Kongnyuy E, Hofman J & van den Broek N (2009) Ensuring effective essential obstetric care in resource poor settings. *BJOG* **116**(Suppl. 1), 41–47.

Li X, Fortney J, Kotelchuck M & Glover L (1996) The postpartum period: the key to maternal mortality. *International Journal of Gynaecology and Obstetrics* **54**, 1–10.

Maine D & Rosenfield A (1999) The safe motherhood initiative: why has it stalled? *American Journal of Public Health* **89**, 480–482.

Mantel G, Buchman E, Reese H & Pattinson RC (1998) Severe acute maternal morbidity: a pilot study of a definition of a near-miss. *British Journal of Obstetrics and Gynaecology* **105**, 985–990.

Maternal Mortality Estimation Interagency Group (MMEIG). (2010) WHO, UNICEF, The World Bank and UN Population Division. Trends in maternal mortality 1990–2008. The World Bank. http://www.unfpa.org/webdav/site/global/shared/documents/publications/2010/trends_matmortality90-08.pdf. [Accessed 8 October 2012].

Maternal Mortality Estimation Interagency Group (MMEIG). (2012) WHO, UNICEF, The World Bank and UN Population Division. Trends in maternal mortality 1990–2010. The World Bank. http://www.unfpa.org/webdav/site/global/shared/documents/publications/2012/Trends_in_maternal_mortality_A4-1.pdf [Accessed 26 June 2012].

Murray S, Davies S, Kumwenda Phiri R & Ahmed Y (2001) Tool for monitoring the effectiveness of district maternity referral systems. *Health Policy and Planning* **16**, 353–361.

Pattinson R & Hall M (2003) Near misses: a useful adjunct to maternal death enquiries. *British Medical Bulletin* **67**, 231–243.

Paxton A, Maine D, Freedman L, Fry D & Lobis S (2005) The evidence for emergency obstetric care. *International Journal of Gynaecology and Obstetrics* **88**, 181–193.

Penney G & Brace V (2007) Near miss audit in obstetrics. *Current Opinion in Obstetrics and Gynecology* **19**, 145–150.

Prual A, Bouvier-Colle M-H, De Bernis L & Bréart G (2000) Severe maternal morbidity from direct obstetric causes in West Africa: incidence and case fatality rates. *Bulletin of the World Health Organization* **78**, 593–602.

Ronsmans C, Graham W & Lancet Maternal Survival Series steering group (2006) Maternal mortality: who, when, where, and why. *Lancet* **368**, 1189–1200.

Say L, Pattinson R & Gulmezoglu A (2004) WHO systematic review of maternal morbidity and mortality: the prevalence of severe acute maternal morbidity (near miss). *Reprod Health* **1**, 3.

UNICEF/WHO/UNFPA. (1997) Guidelines for Monitoring the Availability and use of Obstetric Services. New York: UNICEF.

United Nations General Assembly. (2000) Resolution adopted by the General Assembly: United Nations Millennium Declaration (A/RES/55/2). http://www.un.org/millennium/declaration/ares552e.htm. [Accessed 17 June 2010].

Waterstone M, Bewley S & Wolfe C (2001) Incidence and predictors of severe obstetric morbidity: case-control study. *BMJ* **322**, 1089–1093.

WHO. (1993) ICD-10: International Statistical Classification of Diseases and Health-Related Problems. In Tenth Revision, Vol 2. World Health Organization, Geneva.

WHO. (1994) Indicators to monitor maternal health goals. Report of a technical working group. November 1993. WHO/FHE/MSM/94.14. Geneva. World Health Organisation. https://apps.who.int/rht/documents/MSM94-14/9414.htm [Accessed 15 August 2012].

Zachariah R, Mwagomba B, Misinde D *et al.* (2011) Vital registration in rural Africa: is there a way forward to report on health targets of the Millennium Development Goals? *Transactions of the Royal Society of Tropical Medicine and Hygiene* **105**, 301–309.

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