# Field research

MEDICI CON L'AFRICA
CUAMM
Doctors with Africa

Papers, abstracts, posters
from cooperation activities
in Africa
2015


Photo: © Nicola Berti

# Doctors with Africa CUAMM

Doctors with Africa CUAMM is the largest Italian organization involved in promotion and protection of health in Africa. A long arduous, daily journey alongside the poorest of the poor, living on the fringes and unseen by most eyes. Since 1950, when it was founded under the name of CUAMM (University College for Aspiring Missionaries and Missionary Doctors), Doctors with Africa CUAMM conducts long-term projects, from a development and cooperation perspective, to ensure improved access to health services for all.

In more than 60 years of history:

- 1,569 people have departed to work on projects: 422 of these departed on more than one occasion
- 1,053 students have been accommodated at the college;
- 163 key programmes have been carried out in cooperation with the Italian Foreign Ministry and various international agencies;
- 217 hospitals have been served;
- 41 countries have benefited from intervention;
- 5,021 years of service have been provided, with an average of 3 years per expatriated person

Doctors with Africa Cuamm is currently operating in Angola, Etiopia, Mozambico, Sierra Leone, Sud Sudan, Tanzania, Uganda through:

- 42 key cooperation projects and aroundone hundred micro support actions, trhough which the organization supports:
  - 16 hospitals
  - 34 districts (for public health activities, mother-child care, fight against AIDS, tuberculosis and malaria, training);
  - 3 nursing schools;
  - 2 universities (in Mozambique and Ethiopia).
- 180 international professionals:
  - Doctors
  - Health workers
  - Nursing schools
  - Admin workers
  - 7 logisticians

Doctors with Africa CUAMM has long been active in Europe as well, carrying out projects to raise awareness and educate people on the issues of international health cooperation and equity. In particular, CUAMM works with universities, institutions and other NGOs to bring about a society that understands the value of health as both a fundamental human right and an essential component for human development.

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“Field research is part of a larger research that aims to define new models and measures of cooperation”

*Prof. Anacleto Dal Lago, Doctors with Africa Cuamm*
*December 14, 1984*

# Preface

2015 was a forward-looking year – the year in which the international community laid out clear plans for the future, celebrating a new global Agenda for Sustainable Development that includes a set of goals and specific targets to be achieved by 2030. Some of these goals (known as the SDGs) are well-aligned with the work done by Doctors with Africa CUAMM for years now, for example "zero hunger" (SDG 2) and "good health and well-being" (SDG 3).

2015 was also the year in which we, Doctors with Africa CUAMM, undertook a thorough analysis of our own activities with the help of outside experts, and developed a strategic plan for the future. Based on our resolve to continue tackling poverty and strengthening fragile health care systems, the plan lays out the geographic and thematic priorities that will keep us busy in the African region in upcoming years: over the medium- to long-term, CUAMM will continue to support communities and individuals living in conditions of extreme poverty and vulnerability in the weakest states, in cross-border regions, in remote rural areas and in urban slums. In other words, we will continue to travel down the path we have been on since 1950, when CUAMM's commitment to Africa first began, carrying out activities to improve maternal and child health, to combat the worst infectious disease epidemics, such as HIV/AIDS, tuberculosis and malaria, as well as chronic diseases, and to prevent and treat injuries and acute and chronic malnutrition. But we also plan to invest increasingly in innovation and operational research, because we know how essential they can be for international health cooperation.

Specifically, we intend to use new technologies and innovations to help overhaul health care processes, without ever losing sight of our foremost goal: to support the poorest and most vulnerable. Using the qualitative and quantitative tools provided by operational research, we will undertake rigorous evaluations of these innovations as well as of the outcomes of our projects. And we will continue to work in partnership with others, as part of networks that include young researchers, public and private entities, and international and African research centers.

Finally, 2015 was also a year of research and innovation for CUAMM, a year in which we generated a rich scientific output that we are pleased to share with you here. Indeed, we produced 11 articles for publication in scientific journals, 11 oral presentations for scientific congresses and 17 posters for conferences in Africa, Europe and Asia, all dealing with the topics most vital to us. This allowed us to share our findings, data and methodologies with the broader scientific community and with other institutions and organizations active in the field; it also helped us to evaluate our own work and to gain further insight into the kinds of projects to undertake in coming years – projects whose concrete findings we can then leverage to influence international policy.

**Don Dante Carraro**
*Director, Doctors with Africa CUAMM*

# Operational research in 2015: continuity, innovation and thematic focus

**How to consult this volume in the most fruitful way**

Conducting research is nothing new for Doctors with Africa CUAMM; this is the third collection of research that we have published since 2013[1], driven by the wish to share our experiences, methodologies and findings. But CUAMM embraced research as an integral part of its work long before then, seeing it as an essential component for developing high-quality projects and assessing their effectiveness. Indeed, we have studies that were done as far back as the 1950s, when CUAMM's first doctors set out not only for Africa but also Asia, Oceania and Latin America. These "pioneers" often corresponded with Francesco Canova, our organization's founder, who always applauded and encouraged their research efforts.

2015 was an especially busy year for CUAMM. For the first time, we have included in this volume not only **articles** published in international scientific journals, but also abstracts for oral presentations given at conferences and **posters** displayed in high-level scientific settings. We presented our work both in more traditional European venues and in new hubs for the exchange of ideas and experiences, such as workshops and congresses in Africa and India. Overall, the volume is comprised of **39 pieces** produced by Doctors with Africa CUAMM in 2015, concrete evidence of the **marked upswing in our scientific output** in recent years.

The research topics make clear the strategic priorities of Doctors with Africa CUAMM. More than half of the studies focus on **maternal and child health**, covering subjects that range from the management of obstetric emergencies to solutions to one of the most common gaps in Sub-Saharan Africa, namely the need for **transport systems** able to "refer" patients to the most suitable health centers. There is work on infectious diseases – **Ebola**, of course, but also **HIV** and **tuberculosis** – as well as **nutrition**, with a study on child malnutrition. Other topics include **equity and universal health coverage**, with pieces focused on training and on incentives to encourage the use of health services.

Our focus on the five thematic areas included in **the 2016-2030 strategic plan** recently approved by Doctors with Africa CUAMM – maternal and child health; nutrition; universal health coverage, financial protection and equity; chronic diseases; and infectious and neglected diseases – will vary this year in terms of our work on the ground. This is not, of course, because we intend to "overlook" any of them, but rather to take **a new integrated approach**, following the guidelines laid out in the plan and gradually broadening our work in upcoming years to cover new thematic areas and build bridges among all the areas we work on. For example, nutrition will become a key component in our work to improve fetal and neonatal health, and we will study non-transmissible chronic diseases such as diabetes with a special focus on cases of co-morbidity with infectious diseases such as HIV. Thus our work will slowly branch out into new areas, with the valuable findings of **operational research** there to bolster it.

In conclusion, a few technical notes: this volume is divided into thematic sections based on the five areas mentioned above. Each section includes a selection of journal articles, conference abstracts and posters, each of which indicates the respective country of focus. However, there is also a geographical index at the back of the book for readers who wish to take a country-based approach. Finally, since all of the contributions were presented in international venues, the original texts are in English or, in some cases, Portuguese, but we have provided a brief summary in Italian at the beginning of each.

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[1] Field research. Articles, posters and scientific abstracts from CUAMM's international health care cooperation activities, 2003-2013, Doctors with Africa CUAMM and Operational research in the field. Articles, posters and scientific abstracts from CUAMM's health care cooperation activities in Africa, 2014, Doctors with Africa CUAMM.

# OPERATIONAL RESEARCH AREAS: A MAP

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# MATERNAL AND CHILD HEALTH

## PAPERS

# A hospital-centered approach to improve emergency obstetric care in South Sudan

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- **Date**
  January 2015


Between 1990 and 2014, significant results were obtained for reducing child and maternal mortality, as set by the fourth and fifth Millennium Development Goals. However, there are alarming disparities from country to country and between rural and urban regions with concentrations of mortality in the poorest rural areas of Sub-Saharan Africa and Southern Asia. To address these problems, top priority should be given to interventions designed to make emergency obstetric services (EmOC) available and accessible to everyone.

The study, published in the International Journal of Gynecology and Obstetrics presents data collected in the Yirol hospital of South Sudan, managed by the NGO Doctors with Africa–CUAMM. It considered the number of women admitted to the hospital for delivery in 2012 and highlights improvements over previous years. An increase was seen in the total number of hospital births, which more than doubled over 2009, reaching about 13% of the 8,213 births in the area (compared to 5.9% in 2009).

The causes of this improvement can be found in an approach centered on the hospital's operation. One of its strong points was the introduction of an ambulance in 2011. Though it is also used for other emergencies, the ambulance is managed by the maternity department, providing a free service 24 hours a day which helps women be quickly admitted to the hospital.

The study's goal is to show how in underprivileged remote settings, such as rural South Sudan, a hospital-centered approach, supported by an ambulance referral service to peripheral areas to the main healthcare center, is a major first step to improve emergency obstetric services and directly combat high maternal and child mortality rates

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CLINICAL ARTICLE

# A hospital-centered approach to improve emergency obstetric care in South Sudan

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ABSTRACT

*Objective:* To assess provision of emergency obstetric care (EmOC) in Greater Yirol, South Sudan, after implementation of a hospital-centered intervention with an ambulance referral system. *Methods:* In a descriptive study, data were prospectively recorded for all women referred to Yirol County Hospital for delivery in 2012. An ambulance referral system had been implemented in October 2011. Access to the hospital and ambulance use were free of charge. *Results:* The number of deliveries at Yirol County Hospital increased in 2012 to 1089, corresponding to 13.3% of the 8213 deliveries expected to have occurred in the catchment area. Cesareans were performed for 53 (4.9%) deliveries, corresponding to 0.6% of the expected number of deliveries in the catchment area. Among 950 women who delivered a newborn weighing at least 2500 g at the hospital, 6 (0.6%) intrapartum or very early neonatal deaths occurred. Of 1232 women expected to have major obstetric complications in 2012 in the catchment area, 472 (38.3%) received EmOC at the hospital. Of 115 expected absolute obstetric indications, 114 (99.1%) were treated in the hospital. *Conclusion:* A hospital-centered approach with an ambulance referral system effectively improves the availability of EmOC in underprivileged remote settings.


## 1. Introduction

Improving reproductive health is a global priority. The fourth and fifth Millennium Development Goals aim at a reduction in the mortality of children younger than 5 years (the under-5 mortality rate) by two-thirds and a reduction in the maternal mortality ratio by three-quarters between 1990 and 2015 [1,2]. Big gains have been made for both targets. The global under-5 mortality rate dropped by 41% between 1990 and 2011, from 87 to 51 deaths per 1000 live births [3]. The maternal mortality ratio decreased by 47% between 1990 and 2010, from 400 to 210 maternal deaths per 100 000 live births [3]. However, despite these remarkable improvements, efforts must be intensified to meet these global targets [3,4].

Importantly, there are alarming disparities in maternal and child deaths between countries, and between urban and rural regions. Maternal and child deaths are concentrated in the poorest regions, and in particular in Sub-Saharan Africa and Southern Asia [3]. Worldwide, it has been reported that, by 2011, only half of the women in rural areas in the poorest regions received skilled attendance at delivery compared with 84% in urban areas [3]. In Sub-Saharan Africa and South Asia, the gap between urban and rural areas is even larger [3].

There is a general consensus regarding the priority interventions that are needed to reduce maternal deaths and improve reproductive health generally. These interventions include the provision of universally available and accessible emergency obstetric care (EmOC) of good quality, the presence of a professional skilled birth attendant at all births, and the integration of these key services into health systems [5–8]. To achieve these aims, the existence of an integrated and comprehensive hospital-/community-based health program is generally required [9,10]. However, the implementation of such an integrated approach is frequently unrealistic in neglected, remote settings. Stakeholders of nongovernmental organizations (NGOs) acting in these areas have to prioritize some of the interventions, at least in early phases of implementation.

South Sudan is an underprivileged country in Sub-Saharan Africa. In 2006, the under-5 mortality rate was 135 deaths per 1000 live births, and the maternal mortality rate was 2054 per 100 000 live births [11]. The aim of the present study was to assess provision of EmOC in 2012 in an area of South Sudan, after implementation of a project to improve EmOC in the local community in 2011.

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## 2. Materials and methods

The present descriptive study assessed EmOC in Greater Yirol (Fig. 1), which is part of the Lakes region, one of the 10 states of South Sudan. Pre-interventions evaluations and assessments of the area were performed by two of the authors (F.M. and G.P). Greater Yirol comprises the counties of Yirol West, Yirol East, and Awerial, with a total surface area of 15 084 km$^2$. The population was estimated to be 244 950 in 2012 [12], with 24, 14, and 11 inhabitants per km$^2$ in the three counties, respectively. All connecting roads are rough. There are two hospitals in the area, both of which provide comprehensive EmOC services. One is governmental and is located in Yirol town (where the study took place), and the other is private and located in Mapuordit. Mapuordit is close to the state boundary and connections are problematic, if not impossible during the rainy season, so the hospital there and its catchment area are excluded from the present analysis. Yirol County Hospital covers the remaining catchment area, which has 205 327 inhabitants [13]. In this catchment area, there are also three health centers, two in Yirol West and one in Awerial, but none fulfills the criteria for basic EmOC.

Since 2007, Yirol County Hospital has been run by Doctors with Africa CUAMM. The hospital was renovated in 2007–2008. It has a total capacity of 80 beds, 15 of which are dedicated to the maternity ward. The operating theater is available 24 hours a day and is equipped for cesarean deliveries. Blood transfusions are available 24 hours a day and the service relies on volunteer or family donors. The medical staff includes two permanent expatriate medical doctors, one of whom has experience in obstetrics, and several visiting doctors spending short periods of time at the hospital. The maternity ward is staffed by four qualified midwives, two auxiliary nurses, and seven traditional birth attendants. The hospital costs are covered entirely by Doctors with Africa CUAMM; no support from the Ministry of Health is provided. Direct hospital management costs in 2012 were equivalent to US$ 242 279. Doctors with Africa CUAMM act in strict collaboration with the local health institutions.

In October 2011, an ambulance-based referral system to Yirol County Hospital was implemented. The maternity ward was equipped with a mobile phone, allowing midwives on call to receive and triage phone calls from local citizens, and to contact the drivers to arrange a referral by ambulance when indicated. One ambulance is stationed at the hospital, and three drivers are used to ensure the service is available 24 hours per day. Time from the call for the ambulance to arrival varies substantially (from 5 to 90 minutes) depending on the distance and the weather conditions. All local citizens are allowed to call for the ambulance. The referral system was introduced through systematic provision of information during prenatal care visits and by informing traditional leaders, traditional birth attendants, and local authorities. The service was originally directed at maternal care. It was rapidly extended to sick children, unconscious adults, and accident casualties but remained under the maternity ward coordination. The service is free of charge.

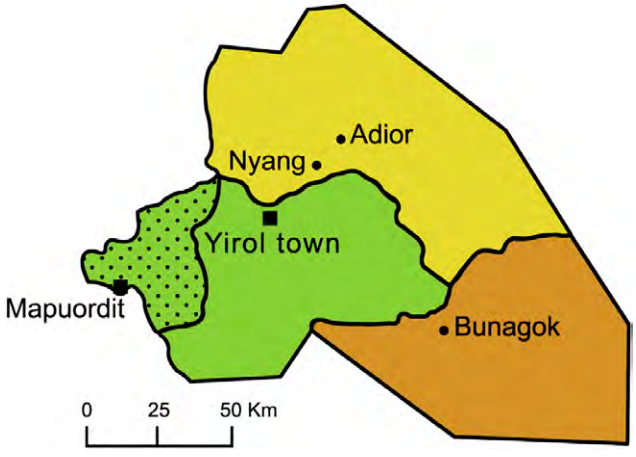


**Fig. 1.** Simplified map of the study area (Greater Yirol, South Sudan). Greater Yirol includes the counties of Yirol West (green), Yirol East (yellow), and Awerial (orange). The dotted area signifies the catchment area of the hospital in Mapuordit, which was not included in the present study. In the catchment area of Yirol Hospital, assisted deliveries could also occur in three non-EmOC health centers (Adior, Nyang, and Bunagok).

The present assessment included all women who were referred to the hospital for delivery between January 1, 2012, and December 31, 2012. On arrival at the hospital, all women were evaluated and managed by a senior expatriate medical doctor (V.P.), who had extensive experience in obstetrics in low-resource settings and had been active at Yirol County Hospital since 2009, and an expatriate resident in gynecology (L.G.). The study was approved by the local institutional review board, and patients or their relatives gave informed consent for participation.

Information about the cases was collected prospectively in a standardized way (L.G). Data regarding the health centers were obtained by regular monitoring of the facilities and using information from the local authorities. Major obstetric complications and absolute (life-threatening) obstetric indications that required obstetric surgery were defined according to the classifications included in the WHO/UN handbook for EmOC monitoring [8]. The data were analyzed using Excel 2010 (Microsoft, Redmond, WA, USA). No measures of statistical significance were calculated.

## 3. Results

The total number of deliveries at Yirol County Hospital was 482 in 2009, 480 in 2010, 744 in 2011, and 1089 in 2012 (Fig. 2). On the basis of an official birth rate of 4% [13], the number of expected deliveries in the hospital catchment area in 2012 was 8213. Assuming that the number of deliveries per year had remained steady, the proportion of all births occurring at the hospital—and so at EmOC facilities—was 5.9% in 2009, 5.8% in 2010, 9.1% in 2011, and 13.3% in 2012.

In 2012, 1089 women delivered in the maternity ward of Yirol County Hospital. An additional 282 women delivered at one of the three health centers offering non-EmOC maternity services. Therefore 1371 deliveries occurred in institutions, corresponding to 16.7% of the expected deliveries in the catchment area. Delivery was by cesarean in 53 (4.9%) of the women who delivered at Yirol County Hospital, corresponding to 0.6% of the expected number of deliveries in the catchment area in 2012. Among the 950 women who delivered a newborn with a birth weight of at least 2500 g in the hospital, 6 (0.6%) intrapartum or very early neonatal deaths occurred (two fresh stillbirths and four early neonatal deaths).

Considering that, based on WHO indicators, 15% of all deliveries are expected to be affected by major obstetric complications [8], 1232 women would have had such complications in the catchment area in 2012. In fact during the study period, 525 major obstetric complications were recorded among 472 women at Yirol County Hospital (Table 1). Therefore, 38.3% of women in the catchment area who would have needed EmOC received such care. Three (0.6%) deaths related to these 525 major obstetric complications were recorded (one prepartum hemorrhage from placental abruption; two postpartum hemorrhages). In addition, three indirect deaths of pregnant women were recorded in the hospital (due to severe anemia, uncontrolled diabetes, and acute heart failure). Blood transfusion was required for 57 (10.9%) major obstetric complications. Of the 472 women who had major obstetric complications, 333 (70.6%) declared their area of residence to be Yirol West, 130 (27.5%) came from Yirol East, and 9 (1.9%) came from Awerial. In total, 221 (46.8%) women with major obstetric complications had been referred by ambulance. This number corresponds to 22.0% of all 1005 ambulance referrals.

The expected proportion of deliveries with absolute obstetric indications is 1.4% [8], so 115 such indications would have been expected in

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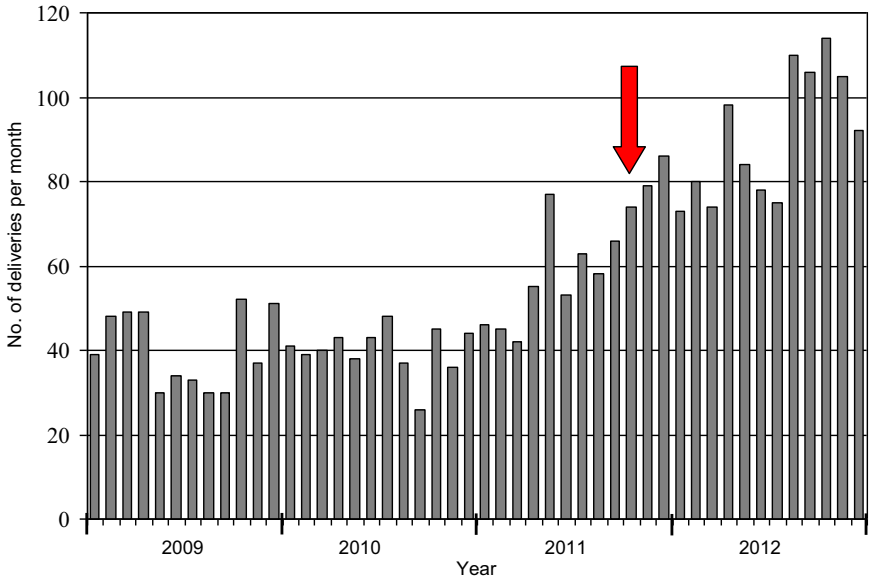


**Fig. 2.** Number of deliveries per month at Yirol County Hospital, South Sudan, 2009–2012. The red arrow indicates the starting point of the ambulance service.

the catchment area in 2012. The total number of women with an absolute obstetric indication treated in the hospital was 114 (13 placenta previa; 20 placental abruption; 19 uncontrollable postpartum hemorrhage; 22 cephalopelvic disproportion or scarred uterus; 35 transverse, brow, or face presentation; and five ruptured uterus). Therefore, 99.1% of the expected absolute obstetric indications were treated at the hospital.

Table 2 summarizes the indicators for EmOC in the area during the study period.

## 4. Discussion

The scenario emerging from the present analysis confirms that Greater Yirol is an underprivileged and neglected area in terms of maternal health. Only one indicator for EmOC was satisfied, and the results for some indicators were alarming. In particular, the number and geographic distribution of EmOC facilities is far below the acceptable level. These findings are even more worrying if the fact that Greater Yirol is a huge area with a low-density population and major transport limitations is considered. Accordingly, the proportion of births occurring in EmOC facilities is very low (13.3%). Moreover, only 38.3% of the need for EmOC is met, and the proportion of cesarean deliveries among all births is also insufficient (0.6% rather than ≥5%).

Nevertheless, the present analysis reveals some important achievements of the project implemented in 2011. Almost all absolute obstetric indications were treated in the EmOC facility, and the proportion of births in EmOC facilities increased from 5.8%–5.9% in 2009–2010 to 13.3% in 2012. This positive trend is confirmed by data from 2013 (unpublished). Moreover, considering the indicators of EmOC quality, the present performance was positive. The direct obstetric case fatality rate was 0.6% (below the recommended maximum level of 1%) and the intrapartum and very early neonatal death rate was 0.6% (a target is not reported for this indicator but 0.6% is fairly low).

**Table 1**
Major obstetric complications in Yirol County Hospital in 2012 (n = 525).

| Obstetric complication | No. (%) |
|---|---|
| Abortion-related complication | 162 (30.9) |
| Prolonged or obstructed labor | 181 (34.5) |
| Postpartum sepsis | 47 (9.0) |
| Hemorrhage | 33 (6.3) |
| Pre-eclampsia or eclampsia | 13 (2.5) |
| Retained placenta | 26 (5.0) |
| Other | 63 (12.0) |

The current situation in Greater Yirol is obviously far from ideal, but a hospital-centered approach seems to be an effective initial step in the implementation of EmOC in disadvantaged areas. Notably, even though the met need for EmOC was below the recommended 100%, a percentage of 38.3% is satisfactory considering the demanding setting. Even if an unmet obstetric need close to 0% could be an overestimation, this result has to be viewed as positive.

The present efforts now need support from the local authorities and other donors to achieve further improvements in EmOC. Existing health centers need to be upgraded so that they can provide basic EmOC services and new, evenly distributed EmOC facilities should be set up to ensure better coverage of the whole area. The analysis of the area of residence for women with major obstetric complications pointed toward an unbalanced distribution. The vast majority of the treated women were from Yirol West, where the hospital is located.

Unfortunately, public health support for the development of local health resources in South Sudan is presently a weak possibility. The public health system collapsed following independence and health services are now mainly provided by NGOs and faith-based organizations. It is estimated that they now provide 80% of the minimum health service package for an estimated 25% of the population. Some progress may now take place with implementation of the Ministry of Health's Health Sector Development Plan 2011–2015 [11], but the role of NGOs and faith-based organizations will remain fundamental.

Identification of the factors that enabled the positive achievements is difficult because of the plurality and concomitancy of the provided measures. However, at least four main factors could have had a role. First, Yirol County Hospital guaranteed good standards of quality. It is qualified as a comprehensive EmOC facility and performed well in the context of quality indicators. Second, access to the hospital was free of charge—presumably one of the most important aspects considering the upset economic situation of the area [13]. Third, the ambulance service probably had an important role. Previous data [12] have demonstrated the outstanding cost-effectiveness of an ambulance service for reproductive health care in remote settings, and a recent independent study from Médecins Sans Frontières [14] confirms these findings. In the present study, an increase in the number of deliveries was observed after implementation of the ambulance service (Fig. 2) and almost half the women with major obstetric complications were referred by

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**Table 2**
Indicators for EmOC (adapted from the WHO/UN handbook for monitoring EmOC [8]) in Greater Yirol in 2012.

| Indicator | Acceptable level | Situation in Greater Yirol | Conclusion |
|---|---|---|---|
| Coverage of EmOC services | ≥5 EmOC facilities (including ≥1 comprehensive) per 500 000 population | Comprehensive EmOC: 4.1 facilities per 500 000<br>Basic EmOC: 0 facilities per 500 000<br>Total EmOC: 4.1 facilities per 500 000[a] | Indicator not met |
| Geographic distribution of EmOC facilities | All subnational areas should have ≥5 EmOC facilities (including ≥1 comprehensive) per 500 000 population | Comprehensive EmOC: 2.4 facilities per 500 000<br>Basic EmOC: 0 facilities per 500 000<br>Total EmOC: 2.4 facilities per 500 000[b] | Indicator not met |
| Proportion of births in EmOC facilities | To be set locally (no target set for Greater Yirol) | 13.3% (1089/8213) | NA |
| Met need for EmOC | 100% of women with major obstetric complications should be treated in EmOC facilities | 38.3% (472/1232) | Indicator not met |
| Cesarean delivery as a proportion of all births | 5%–15% | 0.6% (53/8213) | Indicator not met |
| Direct obstetric case fatality rate | <1% | 0.6% (3/525) | Indicator met |
| Intrapartum and very early neonatal death rate | To be set locally (no target set for Greater Yirol) | 0.6% (6/950) | NA |
| Proportion of deaths attributable to indirect causes in EmOC facilities | No standard can be set | 50.0% (3/6) | NA |

Abbreviations: EmOC, emergency obstetric care; NA, not applicable.
[a] Calculated as the number of EmOCs (n = 2) divided per the population of greater Yirol (n = 244 950) and multiplied per 500 000.
[b] Refers to the catchment area of Yirol hospital. It is calculated as the number of EmOCs (n = 1) divided per the population of the area (n = 205 327) and multiplied per 500 000.

ambulance. Fourth, the local community was included and the local culture respected, which meant that the ambulance service could be implemented rapidly. For instance, blood transfusions and cesarean deliveries are poorly tolerated in the area. Therefore, it was decided to limit their use as much as possible.

Some strengths and limitations of the present study should be acknowledged. A complete baseline assessment before initiation of the intervention was not possible. Only data on the number of deliveries in the hospital were reliably available. Nevertheless, a consistent baseline evaluation would require a long period of observation (several months if not more) without modifying the context. Even though this approach would be more scientifically valid, it would be unacceptable in practice in view of the scarce resources and the urgent need for interventions.

Additionally, the data used for the estimations of community indicators are based on official data from the Ministry of Health, which might be unreliable. The last census was performed in 2008. However, this source of information was the only one available.

A further limitation is related to the area of residence of the referred women. At hospital admission, women stated the payam (administrative level below counties) where they spent the last days before being admitted as their area of residence and not the payam where their family house was located. Therefore, women who had been staying at a relative's house in Yirol town to wait for delivery were erroneously classified as originating from Yirol West. This situation is not uncommon in Greater Yirol, considering the nomad culture of the population. This misclassification would have led to an overestimation of the number of referrals from Yirol West. A more precise picture of the flow of the women would have led to clearer indications for future interventions. Finally, this study is descriptive and no definite conclusions can be drawn regarding a causal relationship between the interventions and the outcome.

Nevertheless, the present study has some strengths. The data are reliable because they were collected by a dedicated gynecology resident at the only EmOC facility in the intervention area. Moreover, because the study period covered a whole year, the sample was large and the confounding effects of seasonal variation could be excluded.

In conclusion, the present study indicates that a hospital-centered approach can be an effective first-step intervention to improve EmOC availability in underprivileged and neglected remote settings provided that it is free of charge, supported by an ambulance service, and properly integrated in the local community. Although valuable as an initial step, a more comprehensive intervention is warranted to improve EmOC indicators.

## Conflict of interest

The authors have no conflicts of interest.

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# Availability, utilisation and quality of maternal and neonatal care services in Karamoja region, Uganda: A health facility-based survey

Maternal and neonatal health indicators in Uganda are very poor: the maternal mortality rate is 438 maternal deaths per 100,000 live births, while the child mortality rate is 54 deaths per 1,000 live births. The study presented here was carried out in the Karamoja region, an area where Doctors with Africa CUAMM has been active for more than 30 years. It aimed to analyse the availability of maternal and neonatal health care services at every level of the health system and to assess both the population's use of them and their quality.

The data collected during the study pointed up a serious lack of infrastructure, tools, medicines and health care personnel, particularly in peripheral health care centers. Use of the services that were available to the community – pre- and post-natal visits and assisted delivery – was low in any case, highlighting the need to further engage with and raise awareness among the local population. Furthermore, there were serious problems with the quality of the services being provided. Indeed, some health care facilities identified as EMOC providers failed to meet the basic criteria for being defined as such. There is therefore a need to re-orient health care personnel towards maternal and child health care in order to achieve the necessary standards of care. There is also an urgent need to improve both the availability of BEmONC services and the local population's access to them.

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REPRODUCTIVE HEALTH

RESEARCH Open Access

# Availability, utilisation and quality of maternal and neonatal health care services in Karamoja region, Uganda: a health facility-based survey

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## Abstract

**Background:** Maternal mortality is persistently high in Uganda. Access to quality emergency obstetrics care (EmOC) is fundamental to reducing maternal and newborn deaths and is a possible way of achieving the target of the fifth millennium development goal. Karamoja region in north-eastern Uganda has consistently demonstrated the nation's lowest scores on key development and health indicators and presents a substantial challenge to Uganda's stability and poverty eradication ambitions. The objectives of this study were: to establish the availability of maternal and neonatal healthcare services at different levels of health units; to assess their utilisation; and to determine the quality of services provided.

**Methods:** A cross sectional study of all health facilities in Napak and Moroto districts was conducted in 2010. Data were collected by reviewing clinical records and registers, interviewing staff and women attending antenatal and postnatal clinics, and by observation. Data were summarized using frequencies and percentages and EmOC indicators were calculated.

**Results:** There were gaps in the availability of essential infrastructure, equipment, supplies, drugs and staff for maternal and neonatal care particularly at health centres (HCs). Utilisation of the available antenatal, intrapartum, and postnatal care services was low. In addition, there were gaps in the quality of care received across these services. Two hospitals, each located in the study districts, qualified as comprehensive EmOC facilities. The number of EmOC facilities per 500,000 population was 3.7. None of the HCs met the criteria for basic EmOC. Assisted vaginal delivery and removal of retained products were the most frequently missing signal functions. Direct obstetric case fatality rate was 3%, the met need for EmOC was 9.9%, and 1.7% of expected deliveries were carried out by caesarean section.

**Conclusions:** To reduce maternal and newborn morbidity and mortality in Karamoja region, there is a need to increase the availability and the accessibility of skilled birth care, address the low utilisation of maternity services and improve the quality of care rendered. There is also a need to improve the availability and accessibility of EmOC services, with particular attention to basic EmOC.

**Keywords:** Maternal health, Rural health, Emergency obstetric care, Uganda

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## Introduction

Uganda has an estimated population of 35.8 million people and is experiencing a rapid population growth. It is a developing country with an estimated per capita income of US$ 510 and a life expectancy at birth of 54 years [1]. The HIV prevalence among the adult population (15–49 years) is about 6.4% [2]. Indicators of maternal and neonatal health (MNH) in the country are also poor. The Maternal Mortality Ratio (MMR) per 100,000 live births is persistently high despite falling from 571 in 1990, to 505 in 2000, and to 438 in 2011 [3,4]. The infant mortality rate is estimated to be 54 per 1,000 live births [3]. Uganda signed on to the Millennium Development Goals (MDGs) of which the targets of the fifth MDG (MDG 5) are to reduce the MMR by 75%, between 1990 and 2015, and to increase coverage of skilled attendance at birth to 95% by 2015 [5]. Achieving these targets in Uganda is challenging because of many barriers to accessing health care as reflected in institutional delivery rate which remains unacceptably low in spite of increases in recent years: 37% in 2001, 42% in 2006 and 57% in 2011 [3].

Barriers to accessing health care services in Uganda include: i) financial limitations; ii) poor geographic accessibility of health facilities in terms of transport and distance; iii) lack of decision making power among women; iv) inability to afford the medical supplies that are often compulsory at public health facilities; v) bad attitude of health workers – including neglect and abuse, and vi) preference for traditional birth attendants (TBAs) [6,7].

Access to quality emergency obstetrics care (EmOC) is fundamental to reducing maternal and newborn mortality rates [8] and is thought to be a possible way of achieving the MDG 5 target [9]. Yet, a national survey conducted to determine availability of EmOC in Uganda concluded that, among health facilities expected to offer basic EmOC, 97.2% were not offering the service. In addition, severe shortcomings in the quality of care were noted [10]. Recent data suggests that there is poor utilisation antenatal care (ANC) in Uganda as only 47% of pregnant women attend four ANC visits [11]. Perhaps the poor ANC coverage contributes in part to the 18% of births assisted by TBAs, 15% by relatives or friends, and 7% without any assistance [3].

The Karamoja region in north-eastern Uganda occupies an area of 35,007 $km^2$ and has a population of 1,294,000 according to 2012 projections [12]. The region has consistently demonstrated the nation's lowest scores on key development and health indicators and presents a substantive challenge to Uganda's stability and poverty eradication ambitions. Over 70% of the population experiences critical food insecurity. In addition to this, decades of armed conflict due to internal and cross-border cattle raiding has resulted in high levels of civil unrest. In attempts to reduce conflict in the region, the government has instituted a policy framework that promotes disarmament and encourages sedentary life styles in place of mobility which is traditionally a characteristic of the region's inhabitants [13]. A combination of different factors severely compromises the effectiveness of MNH care in Karamoja. These include the break-down of the formal health care system, the increased frequency of epidemics, the loss of adult family members to violent death, starvation, outward migration, the disruption of formal marriage structures and the increasing problem of alcohol abuse [14]. In this region for example, coverage for skilled attendance at birth is only 31% compared to the national average of 58% [3].

Doctors with Africa-CUAMM, has been operating in Karamoja for about 30 years; working with district health offices and health facilities to strengthen health systems and to improve access to quality health care [15]. In order to improve planning, monitoring and evaluation of health interventions, Moroto District Health Office in collaboration with Doctors with Africa-CUAMM conducted an in-depth assessment of all health facilities providing MNH services in Moroto district (currently Moroto and Napak districts). The objectives of this study were: i) to establish the availability of MNH care services at different levels of health units; ii) to assess their utilisation; and iii) to determine the quality of services provided.

## Methods

### Study setting

The study was conducted in March 2010 in the Moroto District of Karamoja, which at the time had a population of 276,000 [16]. Shortly after the study period, the district was split into two districts: Moroto and Napak. Karamoja region currently has five other districts: Abim, Amudat, Kaabong, Kotido and Nakapiripirit. The Ugandan health care infrastructure includes village health teams (the lowest level or level I), HCs and hospitals (district/rural, regional and national hospitals). HCs are graded as II, III, or IV, according to the administrative zone served and by the types of services that they provide [17]. HC II provides outpatient care, ANC, immunization and outreach programmes. HC III provides all the services of HC II, plus inpatient care and environmental health. A HC III should be able to function as a basic EmOC (BEmOC) facility [18]. HC IV provides all the services of HCs III, plus surgery, supervises the HCs II and III, and in theory, should be able to function as a comprehensive EmOC (CEmOC) facility [18].

A BEmOC facility is one that is performing all of the following 7 signal functions: i) administration of injectable antibiotics; ii) administration of oxytocic drugs; iii) administration of anticonvulsants; iv) manual removal of the placenta; v) removal of retained products (e.g. manual vacuum aspiration); vi) assisted vaginal deliveries (e.g.

vacuum extraction); and vii) neonatal resuscitation with bag and mask [19]. A comprehensive EmOC facility is one that is performing all signal functions in BEmOC as well as caesarean sections and blood transfusions [19]. In Uganda, MNH services offered at public health facilities are officially free of charge; however, due to frequent shortages of drugs and supplies, patients are sometimes requested to procure missing items.

### Study design

A cross sectional study design at health facility level was used. Data collection tools were adopted mainly from the Safe Motherhood Needs Assessment manual [20] and were locally adapted and pretested. They can be divided into three different pillars: i) Facilities/Health personnel (facility inventory checklist and maternity nurses/midwives interview); ii) Clinical (normal delivery record review, caesarean section record review, eclampsia record review and obstructed labour record review) and iii) Outpatient (antenatal client exit interviews, antenatal client record review, post natal exit interview). Table 1 describes the utilized tools, the target and achieved sample size for each tool and the focus of the tool.

### Sample size, sampling and data analysis

Sample sizes for antenatal client exit interviews and record reviews, normal delivery record reviews, obstructed labour record reviews, postnatal care interviews and caesarean section record reviews were determined using the Taro Yamane formula for a finite population based on data from the routine health information system [21]. The calculated samples were allocated to health facilities in proportion to the number of clients served. For a review of normal deliveries, obstructed labour cases, and caesarean sections, records of deliveries that took place in the past year were systematically sampled. Systematic sampling was also done for antenatal and postnatal exit interviews and antenatal record reviews, although in some cases, the number of clients was insufficient to allow for any sampling and therefore all available clients were interviewed. On average, 5 maternity nurses/midwives per health facility were interviewed. All available records of eclampsia deliveries in the past one year were reviewed. The expected number of deliveries per year (used as denominator for caesarean section rate, ANC coverage, intermittent preventive therapy (IPT) for malaria and postnatal care (PNC) coverage) was estimated by multiplying the crude birth rate (CBR) by the population of the two districts. The CBR was taken to be 4.85% according to Uganda's Health Management Information System manual [22]. Service statistics for facilities over the previous year (2009) were extracted from maternity registers. The items counted were vaginal and caesarean deliveries, direct and indirect obstetric complications and direct and indirect maternal deaths. These data were used to calculate EmOC indicators by following standard United Nations (UN) guidelines [19].

The survey sought to collect information on the number of key health workers related to maternal and neonatal

**Table 1 A description of tools used and the purpose of each tool**

| | Data collection tool | Sample size | | Focus of data collection |
|---|---|---|---|---|
| | | Target | Achieved | |
| **Facility/ Staffing** | Facility management | 20 | 20 | Management of services; staffing; services provided; EmOC services; availability of registers/cards (neonatal register, delivery register, ANC register, family planning register, etc.); key infrastructure; equipment, consumables, essential drugs; facility statistics etc. |
| | Midwife or maternity nurse interview | - | 29 | Practice of midwifery skills by midwives/nurses; knowledge on maternal and neonatal care; recent nurse/midwife practice of life-saving skills |
| **Clinical** | Normal delivery record review | 334 | 337 | Assessment of quality of normal delivery practice using indicators of performance. |
| | Caesarean section record | 140 | 140 | Speed of caesarean section efficiency of caesarean section service; quality of post caesarean section care |
| | Eclampsia record review | – | 9 | Indicators of good management of eclampsia |
| | Obstructed labour record review | 57 | 57 | Outcomes of obstructed labour |
| **Outpatient** | Antenatal care exit interview | 384 | 347 | Services received by antenatal women on the day of the visit or at any time during the current pregnancy; services received during any antenatal visits; knowledge of warning signs during pregnancy. |
| | Antenatal client record review | 384 | 332 | Services received by antenatal clients: Intermittent preventive therapy iron/folic supplementation, tetanus toxoid administration, insecticide-treated bed net provision, provision of de-worming medication, syphilis test, haemoglobin test, etc. |
| | Postnatal exit interview | 379 | 215 | Length of stay at the health facility after delivery; timing after delivery of postpartum visit; postpartum services provided |

health and to assess their retention by estimating the duration of service at their duty stations. This was done for selected staff cadres and was obtained by dividing the number of person months at each duty station by the number of staff whose data on duration of service at duty station was available. Data were collected by two survey teams, each consisting of four trained data collectors and a supervisor. Data entry and analysis were carried out using SPSS version 16. Analysis was done mainly by way of descriptive statistics. The study was approved by the Ugandan National Council for Science and Technology and the Moroto District Health Management Team. Interviewees provided informed consent either by signing or thumb-printing on the consent form.

## Results

### Availability of maternal and neonatal health care services

Moroto and Napak districts combined had 2 general hospitals, 10 HC IIIs and 8 HC IIs. There were no HC IVs. One HC II was in the process of being upgraded to a HC III (and hence was already conducting deliveries).

Normal delivery services were available at only 65% of health facilities; 2 hospitals, 10 HC IIIs and 1 HC II. The two hospitals functioned as full CEmOC facilities; they performed all 9 signal functions in the 3-month period preceding the survey (Table 2). The number of CEmOC facilities per 500,000 population was 3.7 (2/276,000). Each district had a CEmOC facility.

Among HCs that conducted deliveries, none provided all the 7 BEmOC signal functions 3 months prior to the survey (Table 2). The signal functions which require specific manual skills and specific equipment were the least available. No HCs performed vacuum extractions, 18% performed manual vacuum aspiration, and 64% performed manual removal of the placenta within the 3-month period. Almost all the HCs administered injectable anticonvulsants, oxytocics and antibiotics. Five (45%) of the HCs missed 1 or 2 BEmOC signal functions while the rest (55%) missed more than 2 signal functions. Reasons for not having performed signal functions were sought and multiple responses were given (Table 3). Lack of supplies/equipment was the most frequently mentioned reasons for non-performance of signal functions. ANC services, postnatal care and family planning services were available at 75%, 65% and 50% of the health facilities, respectively (Table 4).

**Table 2 Number of facilities by emergency obstetric care signal functions**

| Characteristic | Type of facility | | Total |
|---|---|---|---|
| | Hospital | Health centre* | |
| Number of health units | 2 | 11 | 13 |
| Services provided within the past 3 months (EmOC signal functions) | | | |
| 1. Parental antibiotics | 2 | 11 | 13 |
| 2. Parental oxytocics | 2 | 10 | 12 |
| 3. Parental sedatives/anticonvulsants | 2 | 10 | 12 |
| 4. Manual removal of placenta | 2 | 7 | 9 |
| 5. Removal of retained products | 2 | 4 | 6 |
| 6. Assisted vaginal delivery | 2 | 0 | 2 |
| 7. Neonatal resuscitation with bag and mask | 2 | 5 | 7 |
| 8. Blood transfusion provided | 2 | NA | 2 |
| 9. Caesarean section | 2 | NA | 2 |
| Current EmOC Status | | | |
| Comprehensive EmOC[a] | 2 | NA | 2 |
| Basic-EmOC[b] | 0 | 0 | 0 |
| Non EmOC[c] | 0 | 11 | 11 |

*Health centres providing delivery service (10 HC III and 1 HC II).
[a]if all 1–9 were provided, [b]if only 1–7 were provided, [c]if any of 1–7 was not provided. NA: Not applicable.

### Utilisation of maternal and neonatal health care services

The institutional delivery rate in the study districts combined was 15.4% (Table 4). The population-based caesarean section rate was 1.7% and the met need for EmOC (total complications managed in an EmOC facility as a proportion of expected complicated deliveries in a given population) in the study area was 9.9%. Only 31.7% of women attended at least 4 ANC visits and only 27.7% received two doses of intermittent preventive therapy (IPT) for malaria.

### Quality of maternal and neonatal health care services

The case fatality rate was calculated for those facilities that qualified as CEmOC units and registered maternal deaths. The case fatality rate for direct obstetric complications was 3% compared to a maximum of 1% currently acceptable by the UN (Table 4).

### Facility inventory checklist

Among facilities offering delivery services (n = 13), 54% had a waiting area for maternity clients. A similar percentage of health facilities (54%) had a private examination room, 38% had running water near consultation rooms, 77% had a refrigerator, 23% had an incinerator, and 62% had a toilet. Additionally, 15% of the facilities had a maternity waiting home, 69% had a bed for gynaecological examinations and 54% had a delivery/labour room with a bed. Radio communication systems or a mobile phone, and a car ambulance were available at 46% of the facilities. In general, hospitals had better infrastructure than HCs. Regarding maternity equipment, hospitals were well equipped but deficiencies were noted in HCs whereby 50% lacked basic equipment for normal delivery (scissors, suture materials and a long needle holder). Some HCs lacked equipment for neonatal resuscitation. Hospitals

**Table 3 Reasons for not performing signal functions at health centres**

| Signal function | No. of HCs that did not perform signal function | Number of HCs that did not perform signal function due to[a]: | | |
|---|---|---|---|---|
| | | Lack of trained staff | Supplies/ equipment | No indication |
| Parenteral oxytocics | 1 | 0 | 0 | 1 |
| Manual removal of placenta | 4 | 2 | 0 | 2 |
| Neonatal resuscitation | 6 | 0 | 6 | 2 |
| Removal of retained products | 7 | 6 | 7 | 1 |
| Assisted vaginal delivery | 11 | 5 | 9 | 2 |
| Parenteral anticonvulsants | 1 | 0 | 1 | 0 |
| HCs mentioning the reason for non-performance of any of the functions | | 13 | 23 | 8 |

[a] Multiple responses allowed.
Reasons for not performing signal functions were classified as follows.
a. Lack of trained staff 1) Required health workers are not posted to this facility in adequate numbers (or at all) 2) Authorized cadre is available, but not trained. 3) Providers lack confidence in their own skills. b. Supplies/Equipment Issue. 1). Supplies/equipment are not available, not functional, or broken. 2) Needed drugs are unavailable. c. No Indication - no client needing this procedure came to the facility during this time period.

were well equipped with consumable supplies and drugs while health centres had deficiencies. All facilities conducting deliveries had delivery registers. Neonatal registers were available in 85% of the health units. Among facilities offering ANC, 93% had ANC registers while among those providing family planning, only one did not have a family planning register.

### Staffing

Assessment of staffing (according to staffing norms for MNH) was limited to midwives. In total, the district had a shortage of 47 midwives representing half of the minimum required number. The average duration of service of staff at their present duty stations was assessed. The mean duration was 51 months as compared to 62, 59, and 12 months for clinical officers, midwives/nurses and doctors, respectively.

### Maternity staff interview

Practice of midwifery skills in the previous three months was assessed among 29 nurses and midwives working in the maternity wards. All the staff had practiced intravenous infusions while 90% had practiced focused ANC. About 70% had performed cervical examinations, sutured an episiotomy, used a partograph to monitor labour, performed neonatal resuscitation and sutured vaginal lacerations. Manual removal of the placenta had also been done by 62% of the staff. Skills which were practiced by the least proportion of staff were, performing pap smears and sutures of

**Table 4 Availability and utilisation of maternal and neonatal health over a 3 month period**

| Indicator | Value | Minimum acceptable |
|---|---|---|
| Population | 276000 | - |
| Expected number of deliveries in 2009 | 13386 | - |
| CEmOC facilities per 500,000 population | 3.7 (2/276000) | 1 |
| BEmOC facilities per 500,000 population | 0.0 (0/276000) | 4 |
| Met need for EmOC services | 9.9% (198/2008) | 100% |
| Direct obstetric case fatality rate | 3% (6/198) | <1% |
| Deliveries conducted in EmOC facilities | 10.1% (1352/13386) | 15% |
| Deliveries conducted in all health facilities | 15.4% (2055/13386) | - |
| Population based caesarean section rate | 1.7% (229/13386) | 5% |
| Antenatal care availability | 75% (15/20) | - |
| Antenatal care 1 visit | 61.9% (8288/13386) | - |
| Antenatal care 4 visits | 31.7% (4238/13386) | - |
| Intermittent preventive therapy 1st dose | 47.7% (6386/13386) | - |
| Intermittent preventive therapy 2nd dose | 27.7% (3714/13386) | - |
| Postnatal care availability | 65% (13/20) | - |
| Postnatal care coverage | 31.3% (4187/13386) | - |
| Health facilities with family planning services | 50% (10/20) | - |

3rd/4th degree lacerations, suture of cervical lacerations, vacuum extractions and manual vacuum aspiration (each about 25%). Staff members in hospitals were more likely to have practiced these skills compared to their counterparts at HCs.

The knowledge of maternity staff on various aspects of MNH with a special focus on emergencies was also assessed. Each question had a set of essential solutions that were considered to be sufficient. Seventy nine percent of the staff mentioned all essential aspects of prevention of maternal to child transmission (PMTCT) of HIV. All essential actions in management of postpartum haemorrhage (PPH) and actions to take if a newborn failed to breathe were mentioned by 62% of the interviewees. Actions to be taken for the monitoring of labour and actions to be taken for immediate care of new born were mentioned correctly by 55% and 52% of staff respectively. Less than 50% of the staff mentioned essential actions in management of newborn sepsis; low birth weight babies; incomplete abortion; retained placenta; women with general malaise 24 hours after delivery, and signs of postpartum haemorrhage. In general, staff members in hospitals tended to perform better than those in HCs.

Practice of life saving skills in the past three months was also assessed. About 66% of maternity staff had managed obstructed labour, 45% had managed post-partum haemorrhage, 48% had managed abortion complications, 52% had managed puerperal sepsis and 35% had managed eclampsia. Staff members working in hospitals were more likely to have managed obstetric complications compared to their counterparts in HCs. Postpartum haemorrhage had been managed by only 15% of staff in HCs compared to 89% of staff at hospitals.

### Antenatal client exit interview

Three hundred and forty seven women attending ANC were interviewed (mean age 26 years). Almost all the women (99%) had come to their respective facilities by foot (median walking time 60 minutes, inter-quartile range 30–90). A quarter of the women had a gravidity of >4 and 28.5% were primigravidae. Only 1% did not have any ANC record (either a card or a book). The study investigated services received by antenatal women on the day of the visit or at any time during the current pregnancy. Concerning services received on the day of the visit, the Mother-Baby Package identifies key services that should be provided at every antenatal visit: abdominal examination, foetal heartbeat monitoring and blood pressure recording. These three services were provided to 94%, 89% and 61% of clients, respectively. Only 57% of women had received all the 3 key services. Additionally, antenatal clients were asked if they had received any of the specified services at any time during the current pregnancy. The results are presented in Table 5. Concerning the knowledge of warning signs during pregnancy among antenatal clients, severe vaginal bleeding was mentioned most frequently (57%) followed by postpartum sepsis and premature rupture of membranes (42% each). Prolonged labour was reported by 8% of the respondents. A majority of the respondents (62%) mentioned at least 3 danger signs.

### Antenatal client record review

Three hundred and thirty two records of women attending the ANC clinics were reviewed. The following services had been recorded: provision of IPT (93%); HIV tests (89%); iron/folic supplementation (88%) and tetanus toxoid administration (81%). Other services recorded were insecticide-treated bed net provision (55%), provision of de-worming medication (51%), syphilis tests (4%) and results of haemoglobin tests (1%). The results of syphilis tests were not available on records of all clients attending care at HCs.

### Postnatal care exit interview

Data were collected from 215 women attending postnatal clinics. Their median parity was three. Less than a quarter of the women (23%) had babies aged one week old but a majority (70%) had babies aged more than four weeks. Most of them (88%) attended their first postnatal visit in less than 1 week after delivery but 7% did so more than four weeks after delivery. This means that most of the women had attended the postnatal clinic more than once after delivery. Less than a third (30%) of the women gave birth to the current baby at a health facility. Of all, 87% reported that their baby was examined, 58% discussed with the health worker on how to care for the baby and 58% said breastfeeding was discussed. Only 62% of the women had been given vitamin A tablets and 50% had been talked to about family planning. Only 2% of the women had asked any question to the provider and 6% had felt they had been given a chance to be involved in care provided. A majority (91%) had been asked to come back. Information about having received a blood pressure check, an abdominal examination, a vaginal examination and inquiry about abnormal bleeding during postpartum visits were collected from women with children aged less than one month (65 subjects). Among these, 15% had their blood pressure checked, 25% had an abdominal examination, 17% had a vaginal examination and 22% were asked about abnormal bleeding.

### Normal delivery record review

Records of 273 women were reviewed. More than a half (54%) delivered within one hour of admission; 24% in two to four hours; 14% in five to six hours; and 8% after seven hours. Regarding the length of stay at the health facility after delivery, about half of them (53%) left the facility one day after delivery; 45% left on the day of

**Table 5 Frequency and percent of women by antenatal activities carried out at any visit during the current pregnancy**

| Activity | Number (n = 347) | % (95% CI) |
|---|---|---|
| Received iron supplements | 318 | 92 (88–94) |
| Blood sample taken | 302 | 87 (83–90) |
| Sexually transmitted diseases, HIV/AIDS talked about | 278 | 80 (76–84) |
| Advice on how to take care of your baby provided | 265 | 76 (72–81) |
| Benefit of birth in the health facility discussed | 263 | 76 (71–80) |
| Medical history taken | 252 | 73 (68–77) |
| Family planning discussed | 239 | 69 (64–74) |
| What to do if there is a problem with pregnancy discussed | 238 | 69 (64–73) |
| Place of birth discussed | 236 | 68 (63–73) |
| Information about diet and nutrition provided | 227 | 65 (60–70) |
| Urine sample taken | 25 | 7 (5–11) |

delivery and only 2% left after more than one day. Table 6 shows the frequency and percent of normal delivery records with indicated delivery practice recorded. The most frequently recorded items were oxytocic administration (90%) and status of the placenta and membranes (89%) while the least frequently recorded items were condition of lochia (28%) and at least hourly blood pressure measurement (16%).

### Caesarean section record review

A total of 140 emergency caesarean section records were reviewed. Cervical dilatation had been recorded in 68% of the records. Cephalopelvic disproportion/prolonged labour was the most common indication for caesarean (51%) followed by previous scaring (14%). Other indications were placenta previa/abruption (8%), cord prolapse (6%), foetal distress (5%), breech/malpresentation (5%) and others (11%). Labour monitoring using a partograph had been done in only 29% of these deliveries. The "decision to incision" interval was less than 60 minutes for 76% of women; one hour for 15% and more than one hour for 9% of the cases. Administration of antibiotics had been recorded on most of the charts (89%) but it could not be ascertained, for every record, whether this was done before or after caesarean, or before or after signs of infection. In 9% of the cases reviewed, there was wound infection. The mean duration of hospital stay after caesarean was eight days with most of the women (62%) staying for 7–8 days. There was only one caesarean record (1%) with a maternal death. Foetal outcomes were: live birth (89%), fresh stillbirth (10%) and macerated stillbirth (1%). Foetal outcomes were also assessed according to indication of caesarean. High risks of stillbirth were in placenta previa/abruption (5/11, 46%) and cord prolapse/malpresentation (3/8, 38%).

### Eclampsia record review

Only nine records of eclampsia were encountered. In more than half of the records (56%), no drugs were administered. Antihypertensives were administered in a third of the records while an anticonvulsant (diazepam or magnesium sulphate) was administered in 44%. In 67%, neither blood pressure nor foetal heart beat were checked hourly. In none of the records were both blood pressure and foetal heart beat checked hourly.

### Obstructed labour record review

Fifty seven obstructed labour cases were reviewed. Most (77%) were delivered by caesarean section and 21% by vacuum extraction. Regarding foetal outcomes, 75% of cases resulted in a live birth in good condition (APGAR score 7–10 at 1 minute) while the rest were live births but with a APGAR score <7. Caesarean section was performed within 1 hour of the action line in 52% of the records.

## Discussion

### Availability

The current study shows important aspects of maternal and newborn services provided in the study area. Moroto and Napak districts, combined, exceed the minimum requirement for availability of CEmOC facilities which is 1 per 500,000 population [23]. This is justified given that the districts are very sparsely populated with the services being provided only in the two available hospitals. The population-based caesarean section rate, which is an indicator of accessibility and utilisation of EmOC, is low despite an overall adequate number of CEmOC facilities. This can partly be explained by the sparseness of the population in the districts, poor infrastructure and lack of reliable transportation resulting in poor geographical accessibility to these facilities [24]. The prevalence of high poverty levels in the area does not permit many women to pay for available ambulance services/other means of transportation or to buy supplies/drugs, which are sometimes missing at the facilities [24]. The minimum requirement of five EmOC facilities with at least one CEmOC facility per 500,000 population was not met in the districts. Without an efficient referral system to the hospitals, the lives of mothers and newborns delivering at the HCs is at great risk. Many maternal deaths can be averted if skills to perform assisted vaginal deliveries and removal of retained products are available to women in HCs. The adequate number of CEmOC facilities and inadequate number of BEmOC facilities reported in this study seems to be a common finding in many EmOC surveys [10,25-29]. It is

**Table 6 Frequency and percent of normal delivery records with indicated delivery practice recorded**

| Action recorded | Number (n = 273) | % (95% CI) |
|---|---|---|
| Mother received oxytocic after delivery | 245 | 90 (86–93) |
| Status of the placenta and membranes | 244 | 89 (85–93) |
| Birth weight* | 289 | 86 (82–89) |
| Amount of blood loss | 229 | 84 (79–88) |
| Any APGAR score* | 275 | 82 (77–85) |
| Vaginal examination at least 1 every 4 hours | 187 | 69 (63–74) |
| Foetal heart rate at least hourly | 161 | 59 (53–65) |
| Pelvic exam done on admission | 111 | 41 (35–47) |
| Post-delivery blood pressure of mother | 107 | 39 (34–45) |
| Temperature checked on admission | 106 | 39 (33–45) |
| Post-delivery pulse of mother | 106 | 39 (33–45) |
| Post-delivery mother's temperature | 105 | 39 (33–44) |
| Uterine involution | 98 | 36 (30–42) |
| Condition of lochia | 77 | 28 (23–34) |
| Blood pressure at least hourly | 45 | 16 (13–21) |

*n = 337.

of vital importance to upgrade some HC IIIs to provide BEmOC. However, the utilisation of the available EmOC facilities is still sub-optimal which calls for demand creation. Given that an estimated 74% of maternal deaths could be averted if women have access to interventions for preventing and treating pregnancy and birth complications [8,9], improving the availability of EmOC services is critical to reducing maternal and neonatal mortality.

### Utilisation

Geographical access to health services in Uganda has reportedly improved from 49% to 72% of the population living within 5 km of a health facility, in the period 1990–2005 [30,31]. This would be expected to yield some improvement in access [32]. However, the improvement in geographic accessibility at national level has not resulted in significant levels of utilisation in the study area. The institutional delivery rate of 15% in the study districts is low when compared with the 2011 Ugandan Demographic and Health Survey (DHS) finding of 27% for the Karamoja region [3]. This could be due to the dynamic nature of the population given that it is composed primarily of nomadic pastoralists. The percentage of deliveries conducted in EmOC facilities is lower than the recommended minimum of 15% [23]. In addition, the met need is less than the recommended 100%; all of these factors are indications of poor utilisation of health facilities for maternity services in the study area. A recent review has found that the met need for EmOC is negatively correlated with maternal mortality [33]; further highlighting the critical role of EmOC in maternal mortality reduction.

More efforts are needed to increase uptake of delivery and postnatal care, because most maternal deaths occur during and after delivery [34]. Other studies have shown that lack of knowledge/awareness, perceived poor quality of services, lack of confidentiality and poor attitude of health workers are barriers to health service utilisation [32]. On the other hand, interventions such as the removal of user-fees in government facilities have led to increases in the utilisation of services [35] and the government continues to make an effort to improve the availability of health services [36]. A qualitative study in Moroto and Napak districts found that the main barriers to utilisation of institutional delivery care were outside the scope of the health sector, and called for a multi-sectorial approach in tackling the problem [24]. In order to improve access, the government and development partners will need to continue removing barriers on both the demand and supply sides and address indirect barriers that are outside the scope of the health sector such as insecurity, poverty and shortage of food in the study area [24].

### Quality of care

It is recommended that pregnant women attend a minimum of four ANC visits to allow for appropriate delivery of a complete package of ANC [37]. Utilisation of ANC services is very low in Moroto and Napak districts when compared with the national averages: 62% versus 94% for at least one ANC visit and 32% versus 47% for at least 4 ANC visits [3]. A significant proportion of antenatal clients did not receive all the 3 Mother-Baby Package services, signaling quality gaps in service delivery. Such missed opportunities have been found in other studies in Uganda [38,39].

The prevalence of knowledge of at least three key danger signs during pregnancy among antenatal clients was 62%. Compared with other surveys [39,40], this is not bad. However, prolonged labour (which is one of major causes of maternal mortality in low-income countries) was only reported by 8% of respondents, as reported in other studies [39,40]. Knowledge of key danger signs is essential in prompting women to seek skilled attendance at birth and also to seek referral in case of complications [39,41].

About 31% of mothers who delivered in the study districts visited health facilities for postnatal care. Most mothers who attend these postnatal visits do so during the first week of delivery, probably at the same time when they bring their infants for immunization. At the time of this study, attendance of postnatal visits was being boosted by the associated food distribution; casting doubts on sustainability.

A review of delivery records revealed gaps in quality of intrapartum care. A partograph provides objective data to monitor maternal and foetal wellbeing during labour and serves as a basis for timely clinical decisions to save

the life of the mother and/or the foetus [42]. Yet in this study, a number of clients were not monitored using partographs. Even among those with completed partographs, some were not monitored according to the norm. This may reflect inappropriate management of labour and/or poor use of the instrument. Lack of blank partographs in some health facilities, lack of training in the use of partographs and the fact that some women arrive at the health units while in the 2nd stage of labour could explain why labour monitoring using partographs was not done [43]. A review of immediate postnatal care records revealed gaps in the technical quality of postnatal care provided. Very few women attending postnatal visits had asked any question to the provider or felt they had been given a chance to be involved in care provided. This is a reflection of lack of patient-centred care and poor quality of provider-patient interaction.

A review of management of obstructed labour cases showed that among cases that ended up in caesarean sections, it was only in half of the cases that the intervention was conducted within one hour past the action line. This is an aspect of the third delay (delay in receiving service within health facilities) of the three delays model [43]. This delay should be viewed as a problem with the whole referral system in the district and not just a delay in the hospitals because it's possible that completion of some of the partographs had begun in health centres before referral of clients to hospitals. This view is supported by the results of the promptness of emergency caesarean sections which showed that for 76% of emergency caesarean sections, the baby was delivered within one hour after deciding to perform the procedure. There is some evidence that maternal and newborn outcomes are more likely to be positive if the interval between decision for emergency caesarean section and delivery of the baby is less than 30 minutes [44].

A shortage of midwives in the district was noted. Only half of the minimum required number of midwives was present. When the number of skilled attendants at birth is inadequate, the quality of services is likely to be poor and utilisation will consequently fall. Inadequate staffing, low remuneration and high workload heavily affect quality of care [27,45]. Various strategies are currently being implemented to attract and retain staff in the region [11]. Assessment of the maternal and neonatal care knowledge of maternity staff revealed knowledge gaps for the effective delivery of safe motherhood services. Similar findings have been documented in a study conducted in Soroti; a nearby district [46]. Quality of care can also be linked to availability of physical infrastructure. Physical facilities for maternity care were missing in some facilities with health centres being the most disadvantaged. Lack of infrastructure at health facilities can not only compromise the actual quality of care delivered but also the perceived quality among users, resulting in the underutilisation of services.

This study has a number of limitations. Firstly, the absence of the observation of routine procedures of MNH care delivery is an issue. There may be differences between what people/health workers say they did, and what they actually did. Similarly, when investigating which services women had received, we asked mothers whether they had received services (or checked their files/records). In both cases, this may not be a true reflection of what really happened. Nevertheless, studies done elsewhere have shown that women are good at recalling pregnancy related events [47,48] and hence the effect of these potential limitations on our findings is thought to be minimal. Secondly, women who delivered at some of the HCs were discharged with their partographs and files. Assessment of the quality of normal delivery care at these facilities was therefore limited to the information available in delivery registers. In addition, the average duration of service of staff was obtained by dividing the number of person months at each duty station by the number of staff whose data on duration of service at the duty station was available. This might have resulted in an undercount. Whereas this study was conducted in only two districts, other districts in Karamoja region could benefit from the study's recommendations. There is however a need for further assessments on the availability, utilisation and quality of MNH care services in Karamoja at different levels of health units. This would improve our understanding of the observations presented in this paper, and consequently advance policy-relevant information to decision-makers at all levels.

## Conclusions

This study shows that there were serious challenges to the delivery of maternal health services in Karamoja region. There is an urgent need to upgrade some HC IIIs to meet BEmOC standards. Second, the low coverage of ANC demands an increase in the current efforts to deliver this service. Efforts currently in place (for example food distribution linked to antenatal visits) should be sustained. Thirdly, because the quality, effectiveness, efficiency, accessibility and viability of health services depend mainly on the performance of those who deliver them, staff should be re-oriented on various aspects of maternal and neonatal care and on the importance of providing the required standard of care [49]. This requires the allocation of more resources to recruit skilled personnel and to facilitate a performance improvement process to address the burden of maternal mortality in Karamoja. Monitoring the EmOC relies on proper recording and record keeping. These aspects need to be strengthened at all the health facilities. Lack of equipment, drugs, supplies and poor infrastructure seriously compromise the quality of care provided. With most

deliveries taking place at home, there is need to focus efforts on the demand side. Involving TBAs by encouraging them to refer women to health facilities for delivery has the potential to produce good results [24]. Finally, missed opportunities for delivering health messages to mothers attending ANC were noted. Maternity staff can benefit from having a checklist of key messages they need to share with antenatal and postnatal mothers [50]. Health promotion should also focus on dealing with cultural barriers of delivery in health units and increasing knowledge of the danger signs of pregnancy amongst women. In conclusion, in order to be successful in reducing maternal and newborn morbidity and mortality in this and other areas in Uganda with similar socio-economic profile, there is need to increase availability and accessibility of skilled attendants at birth, address the low utilisation of maternity and postnatal services, and improve the availability and accessibility of EmOC services, with particular attention to BEmOC services.

#### Abbreviations

AIDS: Acquired immunodeficiency syndrome; ANC: Antenatal care; APGAR: Appearance, pulse, grimace, activity and respiration; BEmOC: Basic emergency obstetric care; CEmOC: Comprehensive emergency obstetric care; CUAMM: *Collegio universitario aspiranti medici missionari*; EmOC: Emergency obstetric care; HC: Health centre; HIV: Human immunodeficiency virus; IPT: Intermittent preventive therapy; MDG: Millennium development goal; MMR: Maternal mortality ratio; MNH: Maternal and neonatal health; PMTCT: Prevention of mother to child transmission; PNC: Postnatal care; PPH: Postpartum haemorrhage; TBA: Traditional birth attendant.

#### Competing interests

The authors declare that they have no competing interests.

#### Authors' contributions

PL, GP, FM, GD and AP conceived of the study and participated in its coordination. CW, GP, PL and AP designed the study. CW, GD collected data. CW analysed data. GLQ, CW, GP, AM, BC, GS, AA and KO drafted the manuscript and incorporated all suggestions. All authors made significant contributions to the interpretation of the data and revision of the manuscript. All authors approved the final manuscript.

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MISCELLANEOUS

# Assessing coverage, equity and quality gaps in maternal and neonatal care in Sub-Saharan Africa: an integrated approach

The performance of a health care system can be measured by three parameters: the coverage, equity and quality of health care services. In Sub-Saharan Africa there are still major problems in each of these areas which prevent the respective countries from achieving the Millennium Development Goals related to maternal and neonatal health.

The objective of the study presented here was to analyze these three parameters together, based on the premise that they are closely interrelated and that an analysis of any one of them without the other two makes it difficult to obtain an overall picture of the system.

The study was carried out in three countries where Doctors with Africa CUAMM is active with health care projects: Ethiopia, Uganda and Tanzania. Its findings brought to light serious problems for each of the above-mentioned parameters, and showed how a negative performance related to one of them can negatively influence the other two.

In Uganda, where 42% of women have access to assisted deliveries in health care facilities, much work needs to be done in order to improve the quality of services and programs to encourage access by other groups in the local populations. In Tanzania access to health care is high, but the quality of the services provided is very low, underlining the overall weakness of that country's health care system. In Ethiopia, where 20% of women have access to deliveries in health care facilities, peripheral health care centers are not yet capable of providing emergency obstetric services, and only the most affluent segments of the population have access to hospital care, which is generally of good quality.

In settings that are profoundly different from country to country and from region to region in terms both of health care and territory, taking a multidimensional approach when assessing a health care system makes it possible to get a full picture of it, thereby enabling the planning of specific and effective projects and activities.

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RESEARCH ARTICLE

# Assessing Coverage, Equity and Quality Gaps in Maternal and Neonatal Care in Sub-Saharan Africa: An Integrated Approach

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## Abstract

### Background

Gaps in coverage, equity and quality of health services hinder the achievement of the Millennium Development Goals 4 and 5 in most countries of sub-Saharan Africa as well as in other high-burden countries, yet few studies attempt to assess all these dimensions as part of the situation analysis. We present the base-line data of a project aimed at simultaneously addressing coverage, equity and quality issues in maternal and neonatal health care in five districts belonging to three African countries.

### Methods

Data were collected in cross-sectional studies with three types of tools. Coverage was assessed in three hospitals and 19 health centres (HCs) utilising emergency obstetric and newborn care needs assessment tools developed by the Averting Maternal Death and Disability program. Emergency obstetrics care (EmOC) indicators were calculated. Equity was assessed in three hospitals and 13 HCs by means of proxy wealth indices and women delivering in health facilities were compared with those in the general population to identify inequities. Quality was assessed in three hospitals using the World Health Organization's maternal and neonatal quality of hospital care assessment tool which evaluates the whole range of aspects of obstetric and neonatal care and produces an average score for each main area of care.

### Results

All the three hospitals qualified as comprehensive EmOC facilities but none of the HCs qualified for basic EmOC. None of the districts met the minimum requisites for EmOC indicators.

**Competing Interests:** The authors have declared that no competing interests exist.

In two out of three hospitals, there were major quality gaps which were generally greater in neonatal care, management of emergency and complicated cases and monitoring. Higher access to care was coupled by low quality and good quality by very low access. Stark inequities in utilisation of institutional delivery care were present in all districts and across all health facilities, especially at hospital level.

## Conclusion

Our findings confirm the existence of serious issues regarding coverage, equity and quality of health care for mothers and newborns in all study districts. Gaps in one dimension hinder the potential gains in health outcomes deriving from good performances in other dimensions, thus confirm the need for a three-dimensional profiling of health care provision as a basis for data-driven planning.

## Introduction

Most countries in sub-Saharan Africa (SSA) lag behind in achievement of the Millennium Development Goals (MDGs) 4 and 5 [1, 2] due to complex, and variable across countries, combination of social and health system factors [3, 4]. Among the latter, gaps in coverage, equity and quality of maternal, neonatal and child health services are of paramount importance. Coverage gaps along the continuum of care have long been identified [5] and addressed, with variable results, by nation-wide and internationally driven plans and programs [6]. Dramatic inequities have been acknowledged [7] and are now being increasingly addressed in strategic documents, action plans and related indicators, although so far seldom translated into concrete actions. The importance of the quality gap has been recognized only recently by international agencies and it is now gradually being given greater importance [8, 9].

Indeed, increased coverage of maternal and neonatal health interventions usually results into reduced inequity [10], but it is unlikely to reduce maternal and child deaths if the quality of care rendered is poor [11]. On the other hand, the impact of quality improvement on maternal and newborn health outcomes may be low if access to the service is poor and those at higher risk are excluded [12]. International and national plans and programs, while acknowledging the existence of gaps in all three dimensions of health care provision, tend to focus on each of them in isolation. A health system framework has been proposed to identify bottlenecks for neonatal care [13], yet an integrated approach to the assessment of coverage, equity and quality gaps as a basis for a data-driven planning process is still lacking.

Within a non-governmental organisation (NGO)-run large project aimed at improving maternal and neonatal health in five districts in three SSA countries, a simultaneous assessment of coverage, equity and quality was carried out to inform priority setting and planning. We report on the methods and results of such an approach and discuss its potential use in other high-burden countries.

## Materials and Methods

### Institutional background

Doctors with Africa CUAMM (hereafter referred to as CUAMM) is an Italian NGO which has been supporting health service delivery in Africa for over 60 years. The organisation has adopted the continuum of care approach as the main health service delivery strategy in its

interventions [14]. In 2012, CUAMM started to implement a five-year project focusing on equitable and effective access to safe childbirth and neonatal health services (dubbed "mothers and children first") in three SSA countries: Ethiopia, Tanzania and Uganda. The project aims at achieving improved coverage and quality of essential maternal and neonatal health services and reduced inequity in access to the services.

## Settings

Three countries are involved in the project: Ethiopia, Tanzania and Uganda. All three countries belong to the high mortality (both maternal and under 5), high priority group of countries and are included in internationally driven strategies and initiatives such as the United Nations Secretary General's Strategy [15] and the countdown to 2015 initiative [16], being among the five countries that account for half of Africa's newborn deaths [17]. The project is being conducted in Wolisso, Goro and Wonchi (WGW) districts in Ethiopia, Oyam district in Uganda and Iringa district in Tanzania. All the districts and related health facilities covered by the project in the countries were included in the study.

In order to accelerate reduction in maternal and neonatal mortality, government guidelines in the study countries require all health centres (HCs) and hospitals to provide basic emergency obstetric care (BEmOC) and comprehensive emergency obstetric care (CEmOC), respectively [18–20].

Table 1 presents the main demographic and health system indicators of the three countries and five districts included in the study. All three district hospitals are private-not-for-profit, belong to national health systems, and are supported by CUAMM through provision of expatriate health professionals and variable amounts of financial support.

**Table 1. Main demographic and health system features of the three countries and five districts included in the study.**

| Study countries | | | |
|---|---|---|---|
| **Feature** | **Ethiopia** | **Tanzania** | **Uganda** |
| Maternal mortality ratio per 100,000 live births[a] | 676 | 454 | 438 |
| Neonatal mortality rate per 1,000 live births[a] | 37 | 26 | 27 |
| Stillbirth rate per 1,000 births[b] | 25.6 | 25.6 | 24.8 |
| Health expenditure per capita (US$-in purchasing power parity)[c] | 52 | 107 | 128 |
| National health worker ratio per 10,000 population[d] | 3 | 3 | 14 |
| **Study districts** | | | |
| **Feature** | **Wolisso, Goro & Wonchi districts** | **Iringa district** | **Oyam district** |
| Population (2011) | 372,533 | 276,809 | 378,900 |
| Expected number of births | 13,895 | 10,796 | 18,377 |
| Institutional delivery coverage | 20% [e] | 90%[f] | 42% [e] |
| Number of hospitals | 1 | 1 | 1 |
| Number of health centres (HC III & IV in Uganda) | 16 | 6 | 6 |
| Number of dispensaries/health posts (HC II in Uganda) | 89 | 59 | 17 |

[a] Source: latest demographic and health survey

[b] Source: WHO data on country stillbirth rates per 1000 total births for 2009.

[d] Doctors, nurses and midwives; the recommended number is 23.

[C] Source: 2014 WHO African Region country statistics summary (2002—present).

[e] Based on data from the health management information system

[f] District household survey

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## Data collection tools and methods

A summary of tools and methods of data collection is presented in Table 2. Three types of tools were used to collect cross-sectional baseline data on coverage, equity and quality. With respect to coverage, both availability and actual use of services were assessed using the "needs assessment of emergency obstetric and newborn care" (EmONC) tools developed by the Averting Maternal Death and Disability (AMDD) program of Columbia University [21]. The AMDD's EmONC needs assessment toolkit consists of 10 modules that cover various aspects of the health system including health facility infrastructure, human resources, drugs; equipment and supplies, facility statistics, availability of emergency obstetrics care (EmOC) signal functions, provider knowledge and competency in maternal and newborn care and the referral system. The findings in this paper are based on modules 4 (facility case summary) and 5 (EmOC signal functions). The facility case summary module was completed by reviewing hospital registers and monthly summary sheets. Data on EmOC signal functions were collected at each health facility by interviewing the maternity ward in-charge using the EmOC signal functions module. To improve the accuracy of the data, data collectors, after specific ad hoc training, reviewed several records to double-check the data.

Data from these two modules were used to calculate EmOC indicators according to the standard United Nations guidelines [22] as summarised in S1 Table. EmOC indicators were used to measure the availability, use and, to a limited extent, the quality of maternal and neonatal health services. The EmOC status of a health facility is defined based on whether the facility performed certain signal functions in a three-month period prior to the survey. A BEmOC facility is one that performed all of the following 7 signal functions: i) administration of parenteral antibiotics; ii) administration of oxytocic drugs; iii) administration of anticonvulsants; iv) manual removal of placenta; v) removal of retained products; vi) assisted vaginal delivery; and vii) neonatal resuscitation with bag and mask. A CEmOC facility is one which performed all BEmOC signal functions as well as caesarean sections and blood transfusions [22]. In calculating the proportion of births in EmOC facilities, the met need for EmOC and the caesarean section coverage, we excluded 35.6% and 11% women from the neighbouring districts who sought treatment in the study hospital in Ethiopia and Uganda, respectively. However, we did not exclude women resident in the study districts who might have been treated in neighbouring districts because their number, due to long distances, was negligible. Data from Tanzania were not detailed enough to allow this kind of adjustment. We collected data on coverage between August and November 2012 from one hospital and seven HCs in Ethiopia, and from one hospital and six HCs in each of Uganda and Tanzania.

**Table 2. A summary of the tools and methodology of data collection.**

| Assessment | Tools | Data collection methods | Data collectors | Facilities involved |
|---|---|---|---|---|
| Coverage | Modules 4 and 5 of emergency obstetric and newborn care needs assessment tools by Averting Maternal Death and Disability program | Review of health facility statistics and medical records; interviews with the maternity ward in-charge staff. | Nurses and midwives working in the district and specifically trained. | 3 hospitals and 19 health centres |
| Equity | Proxy wealth indices developed and validated using Demographic and Health Survey data | Interviews with mothers after delivery | Nurses and midwives working in the maternity ward of study facilities | 3 hospitals and 13 health centres |
| Quality | World Health Organization's maternal and neonatal quality of hospital care assessment tool | Review of hospital statistics, medical records, direct observation of cases, and semi-structured interviews with staff and mothers. | A team consisting of an obstetrician, a midwife and a paediatrician/neonatologist | 3 hospitals |

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We assessed equity using proxy wealth indices developed according to the methodology proposed by Pitchforth *et al.* [23] and previously applied to one of the participating hospitals [24]. In brief, the methodology consists of three steps: 1) using household survey data to select a small set of proxy wealth variables; 2) developing a questionnaire using the selected wealth variables; and 3) using the questionnaire to compare the wealth status of women utilising delivery services with that of women in the general population and thereby identifying inequity in the former group. A detailed description can be found in the original papers [23, 24]. The main features of the equity surveys are as summarised in S2 Table. We developed the equity assessment questionnaires based on Demographic and Health Survey (DHS) data of the respective countries. For each country, we selected 6 out of about 40 variables from the DHS; we attributed scores to these variables and assessed the validity and reliability of the scores using Pearson's correlation coefficient (rho) and a measure of agreement (kappa), respectively, with reference to the DHS wealth index. Details regarding the scoring system are available in S3 Table. The selection of only 6 variables was driven by the need to have a simple and easy to administer tool that will cause minimal inconvenience to respondents, yet valid and reliable enough to measure the socio-economic status of the service users. The selected variables were then included in a one-page questionnaire and pretested. Two midwives/nurses were recruited at each health facility and trained on data collection. The data collectors invited all women who had delivered at the health facility to participate in the interview. Equity assessment was conducted between December 2011 and February 2013.

In Uganda and Ethiopia, we collected data at both the hospital and HCs whilst in Tanzania we collected data only at the hospital. This was because a previous household survey in the Iringa District in Tanzania had shown that coverage for institutional delivery was very high (90%) and equitable, but there was some concern that utilisation of the highest level of care, i.e. at hospital, was inequitable.

Data were analysed using Stata version 11. Scores from proxy wealth variables for each woman were summed up and were used to categorize women into wealth groups using the cut-off points for wealth quintiles of women in the household survey data. In the household survey data women are equally distributed in the wealth quintiles (about 20% in each quintile) and any significant shift from this distribution among users of service implies inequity. We compared the household survey data with our collected data using F tests (chi squared tests adjusted for survey design) [25]. In doing so, we used Stata commands that account for the complex sampling design and weighting used in DHS.

Quality was assessed using the World Health Organization's maternal and neonatal quality of hospital care assessment tool [26]. The tool is standard-based and action-oriented and assesses the whole range of obstetric and neonatal care across 17 areas from support services to case management, focusing primarily on safety and effectiveness but also on women's rights to respect, confidentiality and information. More than 400 items were assessed. Four sources of information were utilised: hospital statistics, medical records, direct observation of cases, and semi-structured interviews with staff and mothers. Interviews with staff were mainly aimed at exploring knowledge and use of guidelines, organizational procedures and team work. Interviews with mothers explored obstacles to access and patients' satisfaction with the care and information received. A minimum of ten staff members and ten mothers was interviewed in each hospital. The sample included a variety of women who had experienced either vaginal deliveries or caesarean sections. Mothers with premature babies admitted to the neonatal ward and mothers with babies readmitted to hospital were also represented in the sample.

By combining the information from the various sources, scores ranging from 3 to 0 were attributed to each item based on the following criteria: 3 = care corresponding to international standards (no need for improvement or need for marginal improvement); 2 = substandard

care but no serious hazard to health or violation of human rights; 1 = inadequate care with consequent serious health hazards or violation of women's rights to information, privacy or confidentiality and/or to children's rights; 0 = very poor care with consequent systematic and severe hazards to the health of mothers and/or newborns, e.g. systematic omission of potentially life-saving interventions or lack of essential safety requisites for key procedures such as caesarean section, blood transfusion, neonatal resuscitation, etc. By summing up all scores, an overall average score for each main area of care was obtained. The assessments were conducted by an external multidisciplinary team (an obstetrician, a midwife, and a paediatrician/neonatologist) and involved hospital managers and health professionals. The assessments led to identification of main gaps in quality of care and to a draft plan of actions which included all issues amenable to change based on hospital resources. To ensure consistency of the assessment process, the assessment teams followed the standardized methods described for the tool [26], and one team member participated in all three assessments. Moreover, most team members had previously conducted such assessments jointly in other countries [27]. Quality assessments were conducted between August and October 2012 in all three participating hospitals.

### Ethics statement

Ethical approvals to conduct the studies were obtained from the Oromiya Regional Institutional Review Committee in Ethiopia, the National Council for Science and Technology in Uganda and the National Institute of Medicine in Tanzania. The studies were also approved by the respective district health management teams in each participating district. Participants in the equity and quality studies provided signed informed consent after the objectives and methods of the study had been explained to them. Those who could not write provided verbal consent in the presence of a witness. Coverage and quality assessments relied mainly on observation and review of routine health data and medical records hence did not require informed consent. Verbal consent in the presence of a witness was obtained from interviewed mothers. All collected data were anonymous and did not contain any information that might be used to identify individual patients.

## Results

### Coverage

Table 3 presents a summary of EmOC indicators in the five districts. Regarding the availability of EmOC, all three hospitals performed the nine EmOC signal functions in a three-month period prior to the survey and hence qualified as CEmOC centres. In contrast, none of the 19 HCs performed all the required seven EmOC signal functions to qualify as a BEmOC centre (Fig 1). In Uganda, one HC (a HC level IV) was performing caesarean sections and transfusing blood, but was not able to perform two BEmOC signal functions.

The three districts in Ethiopia showed the largest gap in the provision of EmOC signal functions in HCs. Overall, the biggest gaps were found in the provision of assisted vaginal delivery (AVD) using vacuum or forceps and administration of anticonvulsants for preeclampsia/eclampsia management. No HC was able to perform AVD and only 5 out of 19 HCs had administered anticonvulsants three months prior to the survey. The main reasons why HCs were not able to provide the EmOC signal functions were lack of equipment and supplies, inadequate training and lack of indication as summarised in S4 Table. None of the five districts met the United Nations' (UN) standard of 1 CEmOC and 4 BEmOC facilities per 500,000 inhabitants.

With respect to the actual use of services, the proportion of births occurring in a health facility was 20% in WGW districts in Ethiopia, 42%in Oyam district in Uganda and 90% in Iringa rural district in Tanzania.

**Table 3. Emergency obstetric care (EmOC) indicators in the study districts.**

| EmOC indicator | Acceptable standard | Wolisso, Goro & Wonchi (Ethiopia) | Oyam (Uganda) | Iringa (Tanzania) |
|---|---|---|---|---|
| 1a. Number of comprehensive EmOC facilities per 500,000 population | 1 | 1 | 1 | 1.8 |
| 1b. Number of basic EmOC facilities per 500,000 population | 4 | 0 | 0 | 0 |
| 2. Proportion of all births in EmOC facility | To be set locally | 13.4% (1868/13895) | 8.6% (1584/18377) | 18.0% (1942/10796) |
| 3. Met need for EmOC services | 100% | 17.1% (356/2084) | 13.3% (366/2757) | 19.5% (316/1619) |
| 4. Caesarean sections as a proportion of all births | 5–15% | 2.3% (315/13895) | 2.1% (390/18377) | 5.5% (594/10796) |
| 5. Direct obstetric case fatality rate in EmOC facility | <1 | 0.9% (5/553) | 1.5% (6/411) | 1.6% (5/316) |
| 6. Intrapartum and very early neonatal death rate in EmOC facility | None set | 1.0% (30/2900) | 2.3% (41/1780) | 1.5% (29/1942) |
| 7. Proportion of maternal deaths due to indirect causes in EmOC facility | None set | 16.7% (1/6) | 33.3% (3/9) | 37.5% (3/8) |

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The proportion of births occurring in EmOC facilities, was lowest in Oyam district (8.6%) and highest (18%) in Iringa rural district. The met need for EmOC was less than 20% across all districts. Caesarean section rate in Iringa district (5.5%) was within the recommended range, while in other districts, it was below the minimum recommended rate.

Regarding maternal and perinatal outcomes, the lowest direct obstetric case-fatality rate in EmOC facilities was reported in WGW (0.9% each) and the highest was reported in Iringa (1.6%). Combined intrapartum and very early neonatal death rate in EmOC facilities ranged between 1% in WGW and 2.3 in Oyam. In non-EmOC facilities, this indicator was 0.5% in both WGW and Oyam and 0.2% in Iringa. The number of deaths at HCs was small since most complicated cases are referred to hospital before they die. The highest proportion of maternal deaths due to indirect causes in EmOC facilities was found in Iringa (37.5%) and the lowest in WGW (16.7%); reflecting the prevalence of HIV/AIDS across the districts: 15% in Iringa, 11% in Oyam and 2% in WGW.

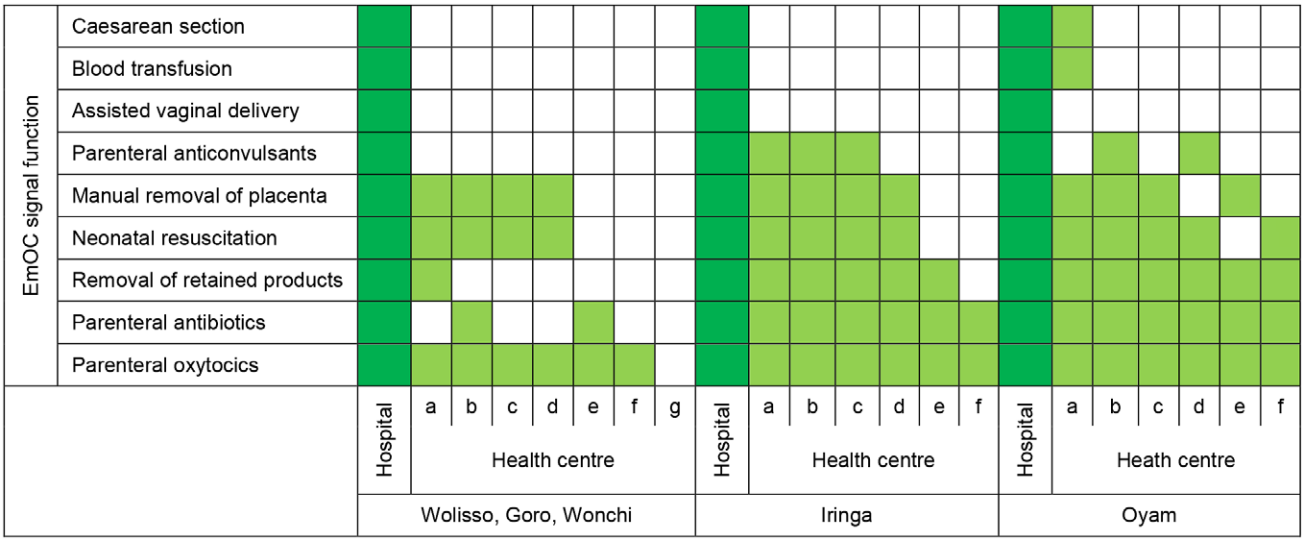


**Fig 1. Performance of EmOC signal functions in a three-month period prior to the survey.**

doi:10.1371/journal.pone.0127827.g001

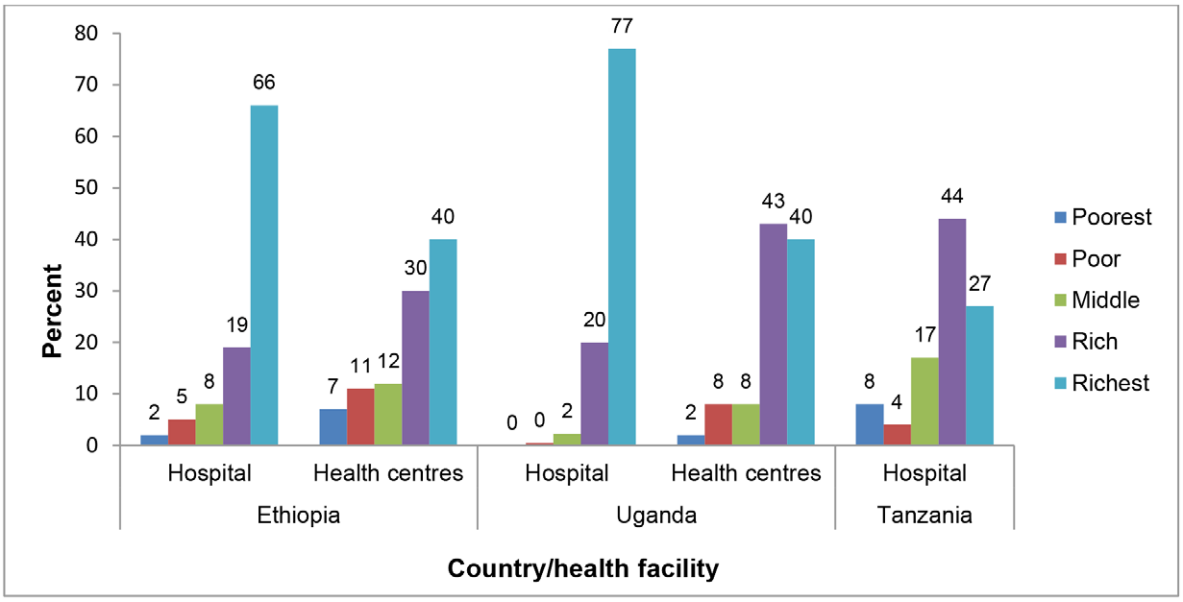


**Fig 2. Distribution of women delivering at health facilities in the study districts into wealth groups.**

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## Equity

Data on equity was collected from a total of 3,643 women: 1,285 in WGW (response rate 94%), 1,354 in Oyam (response rate 81%) and 986 in Iringa (response rate 99%). Fig 2 shows the proportion of women having access to institutional delivery in study districts by wealth quintiles and health facility level (for WGW and Oyam). Data from our study show that in WGW districts, 66% of women who delivered at hospital belonged to the richest wealth group while only 2% belonged to the poorest wealth group. In the same districts, 40% of those who delivered at HCs belonged to the richest group while 7% belonged to the poorest group. Among users of delivery services at the hospital in Oyam, 77% belonged to the richest wealth group whilst less than 1% belonged to the poorest two wealth groups. At HCs, the situation was slightly better as 40% of users belonged to the richest group and 2% belonged to the poorest group. Iringa District was the least inequitable. Overall, the poorest population group was strikingly underrepresented across all the districts (Table 4).

## Quality

The distribution of scores in the main areas included in the assessment of quality of care conducted in the three hospitals belonging to the study districts is shown in Fig 3. Overall, Wolisso hospital had the highest average quality score (2.5/3) while Tosamaganga hospital had the lowest (1.0/3). In two out of three hospitals, important and widespread quality gaps were shown in all 17 areas, with partial exceptions for laboratory equipment and availability of drugs. According to the definitions used, gaps were severe enough to imply serious (score below 2) or systematic and severe (score below 1) hazards to the health of mothers and/or newborns. Overall, gaps were generally greater in neonatal care-which was virtually absent in one hospital, and in other key aspects such as, management of normal labour and obstetric complications. Protocols and monitoring procedures were also lacking in two out of three hospitals. The situation was significantly better in the hospital in Ethiopia where a similar assessment, mainly focused on neonatal care, was carried out about 18 months earlier, leading to substantial improvements

**able 4. Percent distribution of women utilising delivery services and those in the general population in the study districts, by wealth group.**

| 'ealth roup | Wolisso, Goro and Wonchi | | | Oyam | | | Iringa | | |
|---|---|---|---|---|---|---|---|---|---|
| | DHS[a] (n = 1447) | Delivery service users (n = 1305) | P value[d] | DHS[b](n = 1051) | Delivery service users (n = 1352) | P value[d] | DHS[c] (n = 341) | Delivery service users (n = 986) | P Value[d] |
| oorest | 19 | 3 | <0.001 | 20 | 1 | <0.001 | 19 | 8 | <0.001 |
| oor | 21 | 6 | | 20 | 5 | | 24 | 4 | |
| iddle | 21 | 8 | | 20 | 6 | | 17 | 17 | |
| ich | 20 | 20 | | 19 | 35 | | 17 | 44 | |
| ichest | 19 | 63 | | 21 | 52 | | 23 | 27 | |

the 2011 Ethiopia Demographic and Health Survey data of Oromiya Region

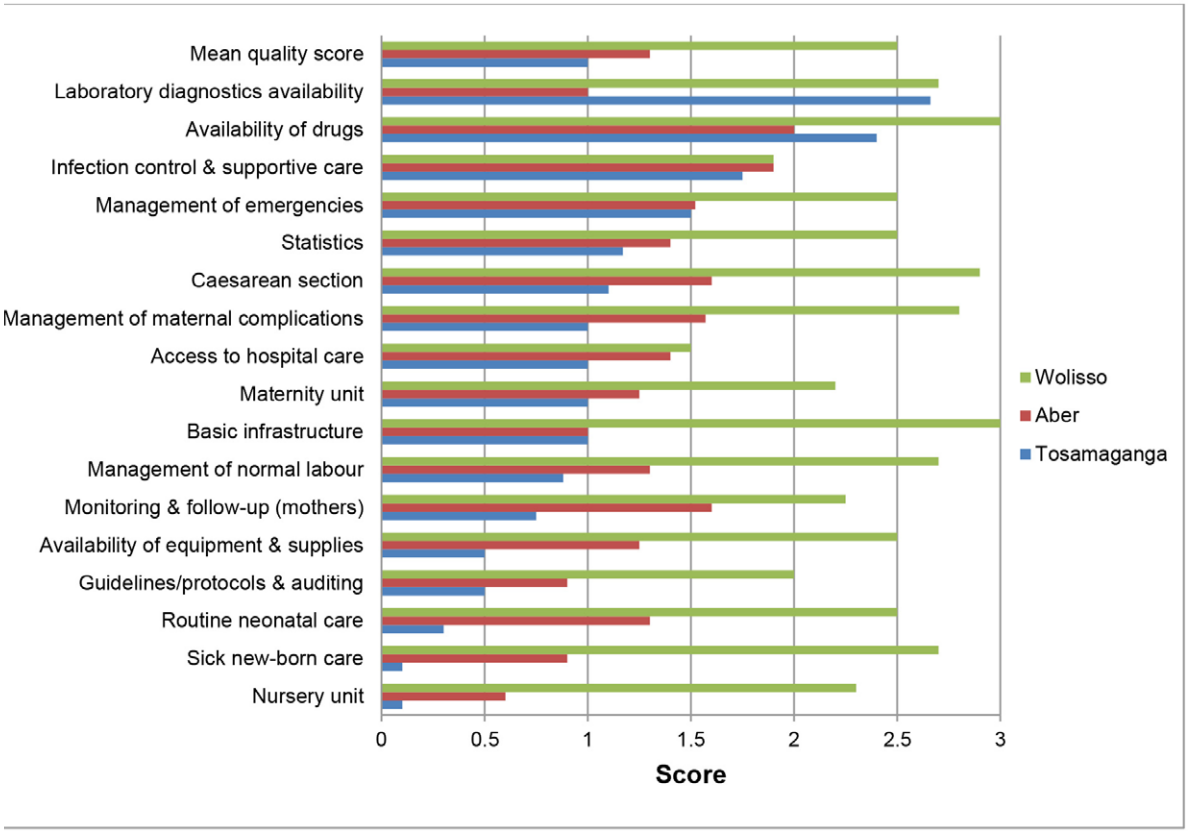
the 2006 Uganda Demographic and Health Survey data of Northern Uganda

he 2010Tanzania Demographic and Health Survey data of Iringa Region

P value from an F test which is a chi squared test adjusted for the complex sampling design used in demographic and health surveys

i:10.1371/journal.pone.0127827.t004

in the care of the normal newborn and in the case management of low birth weight babies. Quality of care at hospital level was reflected in case fatality rates. Besides and beyond safety and effectiveness issues, complaints by mothers included mainly the following: inadequate bath or shower facilities; restricted entry of family members and relatives; staff sometimes not providing enough information or not responding to specific requests (e.g. for pain relief); and lack of respect by staff, including cleaners.




**g 3. Quality of maternal and new-born care services at Wolisso (Ethiopia), Aber (Uganda) and Tosamaganga (Tanzania) hospitals.**

i:10.1371/journal.pone.0127827.g003

**Table 5. Overview of main coverage, equity and quality indicators.**

| Indicator | District | | |
|---|---|---|---|
| | Wolisso, Goro & Wonchi | Oyam | Iringa |
| Coverage | | | |
| Met need for EmOC | 17.1% | 13.3% | 19.5% |
| Caesarean section coverage | 2.3 | 2.1% | 5.5% |
| Equity | | | |
| Percent of women in the lowest two wealth groups | 9% | 6% | 12% |
| Percent of women in the highest two wealth groups | 83% | 87% | 71% |
| Quality | | | |
| Mean quality score (out of 3) | 2.5 | 1.3 | 1.0 |
| Direct obstetric case fatality rate | 0.9% | 1.5% | 1.6% |

doi:10.1371/journal.pone.0127827.t005

## Summary of three-dimension assessment

As shown in Table 5, in none of the districts, both sufficient access and satisfactory quality were ensured. Where good quality of care was provided at hospital level, as in Wolisso Hospital, access to BEmOC facilities was very low at district level. Where access to institutional delivery was high, as in Oyam district in Tanzania, quality of care provided at hospital level was low. The overall score of quality of care was inversely related to case fatality rate at hospital level.

## Action planning

To address the problem of poor availability of EmOC, CUAMM in consultation with district health authorities started a process of supporting the upgrading of HCs to attain BEmOC status in all districts. This included: infrastructural improvements; procurement and supply of missing equipment, supplies and drugs; training of staff; strengthening the referral system including provision of free ambulance services and regular supervision of HCs. Improvement of health information systems to collect high quality data to monitor EmOC indicators was also planned. To improve coverage and address inequity, user fees for maternal complications, including caesarean sections, were removed in all hospitals. Because the EmOC status of a health facility depends on its utilisation, a community mobilisation strategy to increase service use was developed. Additionally, a strategy of geographical targeting was designed whereby poorer and underserved areas of the districts were targeted with demand-side incentives to improve access and use. The incentive package consisted of transport vouchers, supply of baby kits and free motor cycle ambulance for women who choose to deliver in health facilities. Action plans to improve the quality of care by addressing the main gaps identified by the assessment were developed in all three hospitals, starting with a list of priority actions recommended by the assessment team and discussed at the debriefing session after the assessment, and later on finalized and completed. A follow-up assessment was planned within 24 months in both Aber and Tosamaganga hospitals, while in Wolisso, where results of the assessment were satisfactory, only an internal follow-up assessment was planned.

# Discussion

This is to our knowledge the first action-oriented attempt to collect baseline data on coverage, equity and quality of maternal and newborn care in a multi-country sample of health facilities. The approaches that were used to assess these three dimensions of health care proved to be feasible within a relatively limited period of time and were sufficiently informative to provide a

detailed snapshot of the existing challenges in all three dimensions, thus providing a model that could be replicated in other high-burden countries.

Our findings confirm the existence of important gaps in all three dimensions of health care, and the need to address them simultaneously since gaps in one dimension hinder the potential gains in health outcomes deriving from advances and satisfactory performances in other dimensions. The situations we have described are illuminating in this respect. In WGW districts in Ethiopia, where only 20% of women have access to institutional delivery, HCs are not yet able to provide EmOC and hospital care is strikingly restricted to the better-off, and so are the benefits of a generally good quality of care at hospital level. Here the priority is clearly to improve both demand for and provision of antenatal and delivery care, by increasing the number of BEmOC centres and by addressing accessibility issues such as distance. In Uganda, where 42% of women have access to institutional delivery care, further efforts are needed to increase access across all population groups and to improve the quality of care provided at facility level. In Tanzania, where access is high but HCs do not qualify as BEmOC and the quality is very low even at the district hospital, investing in quality is the outstanding priority. The availability of enough CEmOC facilities but a shortage of BEmOC facilities reported in this study appear to be a common finding in many EmOC surveys [28, 29].

Our estimates of met need for EmOC across the three countries are in line with the results of a recent review which has found that the met need for EmOC in low income countries is 21% (interquartile range of 12–31%) [30]. Although the low met need for EmOC is a reflection of poor access to maternal health care, it is also partly due to exclusion from the calculation of some women with obstetric complications who are treated in facilities, mainly HCs, that don't qualify for EmOC. As in our study, assisted vaginal delivery is the least likely signal function to be reported at HCs [28]. This emphasises the need to focus attention on HCs in improving EmOC coverage.

Our findings also show that the relative importance of coverage, equity and quality gaps may be quite variable across countries, and therefore a multi-dimension analytical approach is necessary in order to customize policies and interventions. The reported plans of action in the five project districts reflect how priority actions may be different in situations that may have looked similar at a more traditional analysis based, for example, only on mortality and coverage assessments.

The extent to which low quality hampers the achievement of the desired health outcomes in spite of good access to institutional delivery is striking and confirms the need to ensure effective coverage of perinatal care and not just access to care. Similar conclusions were recently drawn by large scale projects aimed at improving institutional deliveries in other high-burden countries [31]. On the contrary, while better quality of care reflects in much better mortality indicators for both mothers and babies in Wolisso hospital than in the other two hospitals, good quality care provided to less than 20% of women is clearly not enough to reduce overall maternal and neonatal mortality and morbidity at population level, which remains high at both district and country level [32].

As shown in previous quality assessments [27], there may be gaps in infrastructure, commodities and staff that need to be addressed at system level, but several quality gaps appear to be manageable with the existing resources at local level. On the same line, it is worth noting that scoring was generally higher in areas such as availability of laboratory services and drugs, indicating that shortage of commodities is not the only reason for low quality of care.

Our study suffered from a few limitations. Our assessment of equity relied on comparing data collected from service users with historical data collected through household surveys. This method assumes that the wealth status in the population is constant between the time of the household surveys and the time of our surveys. Although some changes might have occurred,

we believe the use of household assets, which reflect wealth that has accumulated over a long period of time, minimised this effect. Measuring coverage relied on routine health data which may not be of good quality [33]; this might have influenced our results. We tried to minimize this effect by triangulating data from different sources including patient files, registers and monthly report summaries. The number of stillbirths and neonatal deaths with missing data on birth weight or timing of deaths might have resulted into underestimation of intrapartum and very early neonatal death rate, especially at Tosamaganga hospital. Assuming that all the cases with missing data were eligible for inclusion, the revised values for intrapartum and very early neonatal death rate would be 1.1%, 2.3% and 2.2% instead of 1.0%, 2.3% and 1.5% for Wolisso, Aber and Tosamaganga hospitals, respectively. In Iringa District, for geographical reasons, some women might be delivering at Iringa Regional Hospital which is located 18 km away from Tosamaganga Hospital. It is therefore possible that we underestimated caesarean section coverage, the proportion of all births in EmOC facility and the met need for EmOC services. This observation may also partly explain the shape of the equity graph for Iringa: some women in the highest wealth group may have delivered at the regional hospital. However, results would not have changed considerably and, most important, the main conclusions would have remained unchanged.

Our findings provide evidence that a three-dimensional approach to improving maternal and neonatal health is necessary, otherwise the desired health outcomes may not be achieved either because most of the population has no access to health care or because once access is ensured, the quality of care provided is poor. Although this evidence is not surprising, so far too little has been done to comprehensively assess coverage, equity and quality of services for mothers and newborn babies so as to identify, address and mitigate the existing gaps in all these dimensions.

The project has now moved to implementing actions to address the causes of the gaps in coverage, equity and quality which have been identified. Some of the underlying causes pertain to distal determinants and demand issues such as extreme poverty, food insecurity, low education, cultural obstacles to adequate reproductive health and insufficient transport, and therefore need to be addressed by "whole government" policies [34]. Others regard key health system components, from financing to procurement of commodities, to training and deployment of human resources, health information system and delivery modes [34]. Although most of the issues need to be addressed by national governments, several actions can be effectively taken at the local level, in collaboration with local communities, health authorities, managers and health professionals [35].

## Supporting Information

**S1 Table. Formulae used to calculate EmOC indicators.** [a]Crude birth rate x district population [b] Direct obstetric complications included: Antepartum haemorrhage, postpartum haemorrhage/retained placenta, obstructed/prolonged labour, raptured uterus, postpartum sepsis, severe pre-eclampsia/eclampsia, severe complications of abortion and ectopic pregnancy. [c] Intrapartum deaths and neonates with missing birth weight or timing of foetal deaths were excluded from analysis. The number of stillbirth and neonates with unspecified weight or timing of deaths in EmoC facilities were: 13 in Tanzania, 5 in Uganda and 3 in Ethiopia.
(DOCX)

**S2 Table. Main features of the equity surveys.**
(DOCX)

**S3 Table. Assigning scores and weights to selected variables.**
(DOCX)

**S4 Table. Reasons for not performing signal functions at health centres.** [a] Multiple responses allowed. Reasons for not performing signal functions were classified as follows. a. Availability of human resources. 1. Required health workers are not posted to this facility in adequate numbers (or at all). b. Training issues 1. Authorized cadre is available, but not trained 2. Providers lack confidence in their own skills c. Supplies/Equipment Issue 1. Supplies/equipment are not available, not functional, or broken 2. Needed drugs are unavailable d. Management Issues 1. Providers desire compensation to perform this function 2. Providers are encouraged to perform alternative procedures 3. Providers uncomfortable or unwilling to perform procedure for reasons unrelated to training 4. Lack of supervision e. Policy issues- national or facility policies do not allow function to be performed f. No Indication—no client needing this procedure came to the facility during this time period.
(DOCX)

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## Author Contributions

Conceived and designed the experiments: CW GP DDR FM AA MS GT. Performed the experiments: CW FC TA BT OE MS FK JT. Analyzed the data: CW GP DDR FM AA MS GT. Contributed reagents/materials/analysis tools: CW GP DDR AA FC TA BT OE MS FK JT. Wrote the paper: CW GP DDR AA FC TA BT OE MS FK JT. Coordinated the studies: GP FM AA FC BT MS.

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# Determinants of utilisation of antenatal care and skilled birth attendant at delivery in South West Shoa Zone, Ethiopia: a cross sectional study


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Ethiopia has one of the highest maternal mortality rates in the world (676 maternal deaths per 100,000 live births) and is one of the ten countries in the world that comprise 58% of global maternal deaths. Problems of coverage are certainly among the factors contributing to this dire mortality rate. Indeed, pregnant women's failure to use the health care services that are available (prenatal visits and deliveries assisted by qualified staff) clearly has a negative outcome; having at least four prenatal visits and giving birth in a facility staffed by qualified health care workers makes it possible, in fact, to cut down on the mortality rate because the latter are able to prevent many of the causes of maternal death.

The study presented here investigated which factors determine whether or not health services (a minimum of four prenatal visits and an assisted delivery) are used by women in the Ethiopian region of Shoa. Wolisso, Goro and Wonchi Districts were analyzed in particular, and 500 women of childbearing age (15 to 49 years old) were interviewed for the study.

45.5% of the women had had at least 4 prenatal visits and 28.6% had given birth with the assistance of a health care professional. The reasons underlying the decision to use the services were primarily both cultural (being aware of the recommended number of prenatal visits and of possible complications associated with non-assisted deliveries, having a positive attitude about motherhood) and economic (well-being). The reasons underlying the non-use of maternal health care services included the age of women and pregnancy outside of marriage. The distance to be travelled in order to reach health care facilities was an additional factor: indeed 42% of the women participating in the study have to walk for more than an hour to get to the nearest health care center.

It is therefore crucial to take actions to make young women aware of the importance of maternal health care, as well as to involve their husbands, families and the entire community.

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# Determinants of utilisation of antenatal care and skilled birth attendant at delivery in South West Shoa Zone, Ethiopia: a cross sectional study

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## Abstract

**Background:** Ethiopia has high maternal mortality ratio and poor access to maternal health services. Attendance of at least four antenatal care (ANC) visits and delivery by a skilled birth attendant (SBA) are important in preventing maternal deaths. Understanding the reasons behind the poor use of these services is important in designing strategies to address the problem. This study aimed to determine the coverage of at least four ANC visits and delivery by a SBA and to identify determinants of utilisation of these services in three districts in South West Shoa Zone, Ethiopia.

**Methods:** A cross-sectional survey of 500 women aged 15–49 years with a delivery in two years prior to the survey was conducted in Wolisso, Wonchi and Goro districts in February 2013. Data were collected using an interviewer administered questionnaire. Logistic regression models were used to explore determinants of ANC attendance and SBA at delivery.

**Results:** Coverage of at least four ANC visits and SBA at delivery were 45.5 and 28.6 %, respectively. Most institutional deliveries (69 %) occurred at the single hospital that serves the study districts. Attendance of at least four ANC visits was positively associated with wealth status, knowledge of the recommended number of ANC visits, and attitude towards maternal health care, but was negatively associated with woman's age. SBA at delivery was negatively associated with parity and time to the health facility, but was positively associated with urban residence, wealth, knowledge of the recommended number of ANC visits, perceived good quality of maternal health services, experience of a pregnancy/delivery related problem, involvement of the partner/family in decision making on delivery place, and birth preparedness.

**Conclusions:** Raising awareness about the minimum recommended number of ANC visits, tackling geographical inaccessibility, improving the quality of care, encouraging pregnant women to have a birth and complication readiness plan and community mobilisation targeting women, husbands, and families for their involvement in maternal health care have the potential to increase use of maternal health services in this setting. Furthermore, supporting health centres to increase uptake of institutional delivery services may rapidly increase coverage of delivery by SBA and reduce inequity.

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## Background

The fifth millennium development goal target is to reduce maternal mortality ratio (MMR) by 75 % between 1990 and 2015. Globally, it is estimated 289,000 maternal deaths occurred in 2013; a decline of 45 % from 1990 [1]. Sub-Saharan Africa accounted for 62 % of the global burden of maternal deaths. This region had the highest MMR at 500 maternal deaths per 100 000 live births compared to the global average of 210 maternal deaths per 100,000 live births [1]. Ethiopia has one of the highest MMRs worldwide: 676 per 100,000 live births [2]; positioning the country among the 10 countries that contribute to 58 % of all maternal deaths worldwide [1]. Ethiopia is also among the 10 countries with the highest numbers of intrapartum-related neonatal deaths and intrapartum stillbirths [3]. The country has a neonatal mortality rate 37 per 1000 live births, with little reduction since the year 2000 [2], and is one of the five countries that contribute to half of Africa's newborn deaths [4].

Monitoring maternal mortality is expensive and technically demanding. Coverage indicators are therefore often used as good proxies to monitor mortality reduction. Increases in coverage signify that policies and delivery strategies are successfully reaching target populations [5]. The high maternal mortality in Ethiopia is reflective of the low coverage of quality maternal health services. Antenatal care (ANC) and skilled attendance at delivery are critical factors in preventing maternal deaths [6, 7]. Nevertheless, although, 42.6 % of women in Ethiopia attend at least one antenatal care visit, only 19.1 % complete the recommended minimum four visits. Moreover, only 10 % of deliveries are attended to by a skilled birth attendant (SBA) and the proportion of births by caesarean section is 1.5 % [2]; which is among the lowest rates worldwide and unlikely to cover the needs [8, 9]. Health system resources are scarce in Ethiopia: total health expenditure per capita per year is around 16 US dollars [10]. Even though the Ethiopian Government has in the past launched various Health Sector Development Programmes to address the health challenges in the county, such programmes have suffered from implementation problems [11].

Studies in Ethiopia have found that being in a rural area, having no education, being in lower wealth groups, being older, having a higher parity, staying far away from the health facility, not attending ANC, and not having knowledge about pregnancy related services are some of the factors associated with low utilisation of SBAs [12–18]. However, the role of some factors such as decision making regarding place of delivery, attitude towards maternal health care and birth preparedness have rarely been investigated. Additionally, although a number of studies have assessed determinants of receiving ANC in general in Ethiopia [15, 18–20]; there is lack of studies from the country that have explored determinants of attendance of at least four ANC visits.

This paper presents the results of a survey that was conducted in the context of a three year maternal and neonatal health project funded by the Italian International Cooperation in Wolisso, Goro and Wonchi districts (so-called *woredas* in Oromo language), and implemented by the non-governmental organisation Doctors with Africa CAUMM. The organisation has been supporting health services management and delivery in Ethiopia since 1984, and has adopted the continuum of care approach as its main health service delivery strategy [21]. The objectives of this survey were to determine the coverage of at least four ANC visits and delivery by a SBA, and to explore determinants of utilisation of these services in the three districts in Ethiopia.

## Methods

### Study design and setting

This is a cross sectional survey of women of reproductive age (15–49 years) who had delivered in the two years prior to the survey. The study was conducted in Wolisso, Goro and Wonchi districts of South West Shoa Zone, Oromiya region in central Ethiopia. The three districts have a combined population of about 372,478 inhabitants and are served by one hospital which also acts as a zonal referral hospital, 16 health centres (HCs), and 89 health posts. In Ethiopia, maternity services are usually provided at HCs as well as at hospitals by a health professional.

### Sample size and sampling

The sample size was estimated assuming institutional delivery coverage of 20 % based on the routine health data for the three districts, an absolute precision of 0.05, and a Z score value of 1.96 for 95 % confidence interval (CI). The sample size was further adjusted for a design effect of 2 yielding a minimum required sample size of 492. Multistage sampling using a modified Expanded Program for Immunisation's random walk method [22] was used to select study subjects. The first stage involved selection of villages and the second stage involved selection of interviewees. First, the calculated sample size was allocated in proportion to the population in each district. Within each district, villages were randomly selected by probability proportionate to size. A total of twenty five villages were selected and 20 women were interviewed from each village. In each selected village, the centre was identified and while there, a pen was spun to identify the random walking direction. One team of data collectors began walking from the centre and visited consecutive households in the direction of the pen and another team went to the end of the village

and visited consecutive houses towards the centre. One eligible woman was interviewed per household.

### Data collection and tools

Data were collected in February 2013 by trained data collectors utilising interviewer administered questionnaires that were adapted using the UNICEF's Multiple Cluster Indicator Survey questionnaires and JHPIEGO's tools for monitoring birth preparedness and complication readiness [23]. The questionnaires were pretested and translated into Oromo language. Two questionnaires were used: a household questionnaire which collected data on household characteristics, asset ownership and access to water and sanitation facilities; and a women's questionnaire which collected data on characteristics of women and various aspects of maternal health care. Data were then entered in duplicate into EpiData version 3.1 and validated.

### Measures

The outcome variables were: (1) attendance of at least four ANC visits provided by a health professional or a health extension worker, and (2) delivery care by a SBA i.e. a doctor, nurse, midwife, or a health officer. Wealth index, which is a composite measure of a household's cumulative living standard, was derived from factor analysis of household assets, housing material, and access to water and sanitation services [24, 25]. Attitude score was designed to assess attitude on three aspects of maternal health: birth preparedness, male involvement, and barriers to institutional delivery and it was derived from factor analysis of eight Likert-scale statements [23]. Barriers to institutional delivery focused on three aspects: costs, difficulties in getting to the health facility and handling of women by health facility staff. Male involvement focused on perception towards the husband accompanying his wife to the health facility for ANC and delivery, and the role of men in childbirth [23]. The scores were ranked into tertiles. Being well prepared for the birth of the baby was defined as having done any two of the following during pregnancy: identification of transport, saving money, identification of a blood donor, deciding on the facility where the baby will be born, and identification of a SBA [23].

### Data analysis

Data were analysed in Stata version 12 using survey commands to account for the complex sampling scheme by specifying the stratifying, clustering and weighting variables. Specifying the cluster and strata using the *svyset* command followed by use of the *svy* prefix with estimation commands in Stata adjusts for standard errors and produces confidence intervals and *p*-values that are unbiased by the survey design [26]. Weighting was performed using the inverse of the probability of selection in each residence (urban/rural), to correct for a slight oversampling in urban areas. Characteristics of participants were summarised using percentages. Because the sample size had been calculated to estimate prevalence as opposed to two sample comparisons (i.e. attendance of four ANC visits and delivery by a SBA; both dichotomous), post-hoc calculations of the power of the study to detect significant differences between comparison groups at 5 % level were performed. The results showed that the power was above 83 % for almost all the key variables (see additional file 1). Logistic regression models were used to obtain unadjusted and adjusted odds ratios with 95 % CIs for the associations between various factors and each of the outcome variables. Variables with $p < 0.1$ in unadjusted analysis were included in multivariate analysis which was performed using the forwards fitting approach [27]. The significance of each variable in the model was assessed using adjusted Wald test to obtain an F statistic and its associated $p$ value. All $p < 0.05$ (2-sided) values were considered statistically significant.

### Ethical considerations

The study protocol and tools were approved by the Oromiya Regional Institutional Review Board and by the district health management teams of the study districts. Due to low literacy levels in the study setting, participants provided verbal informed consent after they had been introduced to the purpose of the study and informed about their right to interrupt the interview at any time or decline to be interviewed without any future prejudice.

## Results

### Characteristics of participants

Five hundred women participated in the survey and only three women approached for an interview (0.6 %) declined to participate. Among the participants, 45.5 % (95 % CI 38.0–53.0 %) attended at least four ANC visits (hereafter referred to as ANC) and 28.6 % (95 % CI 17.6–39.6 %) delivered with a SBA. Most women (54.4 %) were assisted at delivery by traditional birth attendants (TBAs) but a significant proportion (15.1 %) were assisted by relatives/friends with the remainder being assisted by health extension workers or no one. Among women who delivered in health facilities, 69.4 % delivered at the hospital, 27.1 % in HCs and the rest in other facilities. Table 1 presents a summary of participants' characteristics. Most of the participants were from Wolisso District (55.6 %); rural dwellers (86.3 %); of Oromo ethnicity (86.6 %); uneducated (52.3 %); orthodox Christians (51.8 %); with a partner with at least primary education (77 %); and married (96.4 %). Less than a half (48.8 %) knew the minimum

**Table 1** Percent distribution of women by antenatal care attendance and delivery by skilled provider

| Characteristics | Attended four ANC visits | | Delivered by skilled provider | | Total (*n* = 500) |
|---|---|---|---|---|---|
| | No (*n* = 263) | Yes (*n* = 237) | No (*n* = 335) | Yes (*n* = 165) | |
| District | | | | | |
| Wolisso | 55.2 | 56.2 | 52.5 | 63.5 | 55.6 |
| Goro | 15.0 | 16.5 | 15.2 | 16.7 | 15.7 |
| Wonchi | 29.9 | 27.3 | 32.3 | 19.7 | 28.7 |
| Urban residence | 7.1 | 21.9 | 2.2 | 42.7 | 13.8 |
| Non Oromo ethnicity | 10.3 | 17.1 | 10.1 | 21.5 | 13.4 |
| Household size | | | | | |
| 2–3 | 13.2 | 21.1 | 10.9 | 31.5 | 16.8 |
| 4–5 | 33.2 | 37.0 | 35.0 | 34.9 | 34.9 |
| >5 | 53.6 | 41.9 | 54.1 | 33.6 | 48.3 |
| Wealth index quintile | | | | | |
| Lowest | 26.5 | 11.8 | 25.4 | 6.0 | 19.8 |
| Second | 19.4 | 21.1 | 24.6 | 9.0 | 20.2 |
| Middle | 23.7 | 15.5 | 24.3 | 9.0 | 19.9 |
| Fourth | 18.8 | 21.8 | 18.0 | 25.6 | 20.2 |
| Highest | 11.6 | 29.8 | 7.7 | 50.3 | 19.9 |
| Age in years | | | | | |
| 15–24 | 21.4 | 32.2 | 22.8 | 35.0 | 26.3 |
| 25–29 | 34.5 | 40.5 | 38.6 | 33.7 | 37.2 |
| 30–34 | 22.2 | 14.3 | 19.4 | 16.7 | 18.6 |
| 35–49 | 22.0 | 13.0 | 19.2 | 14.6 | 17.9 |
| Parity | | | | | |
| 1 | 15.5 | 24.8 | 12.5 | 37.8 | 19.8 |
| 2–3 | 28.0 | 30.9 | 29.1 | 30.0 | 29.3 |
| 4–5 | 32.1 | 30.0 | 36.2 | 18.5 | 31.1 |
| >5 | 24.4 | 14.3 | 22.2 | 13.7 | 19.8 |
| Woman's education level | | | | | |
| None | 59.4 | 43.8 | 60.3 | 32.3 | 52.3 |
| Primary | 33.9 | 41.2 | 34.8 | 43.4 | 137.2 |
| Secondary/higher | 6.7 | 15.0 | 4.9 | 24.3 | 10.5 |
| Partner's education level | | | | | |
| None/no partner | 27.2 | 17.9 | 28.5 | 9.2 | 23.0 |
| Primary | 57.2 | 56.4 | 59.5 | 50.2 | 56.8 |
| Secondary/higher | 15.6 | 25.7 | 12.0 | 40.6 | 20.2 |
| Marital status | | | | | |
| Married | 95.9 | 97.0 | 95.7 | 198.3 | 96.4 |
| Single | 4.1 | 3.0 | 4.3 | 1.7 | 3.6 |
| Religion | | | | | |
| Orthodox Christian | 54.0 | 49.2 | 53.0 | 48.9 | 51.8 |
| Protestant | 22.7 | 26.3 | 23.0 | 27.7 | 24.4 |
| Muslim | 23.3 | 24.5 | 24.0 | 23.4 | 23.8 |
| Knows the required number of ANC visits | 34.9 | 65.4 | 41.8 | 66.3 | 48.8 |
| Knows ≥3 pregnancy danger signs | 19.4 | 27.9 | 19.3 | 33.3 | 23.3 |

**Table 1** Percent distribution of women by antenatal care attendance and delivery by skilled provider *(Continued)*

| | | | | | |
|---|---|---|---|---|---|
| Time to nearest health facility | | | | | |
| <30 min | 25.3 | 44.2 | 22.1 | 63.4 | 33.9 |
| 30–59 min | 24.2 | 23.1 | 26.6 | 16.5 | 23.7 |
| ≥60 min | 50.5 | 32.7 | 51.3 | 20.1 | 42.4 |
| Perceived quality of care at nearest facility | | | | | |
| Average/poor/don't know | 44.2 | 34.2 | 43.5 | 30.0 | 39.7 |
| Good | 44.8 | 46.4 | 46.3 | 43.6 | 45.5 |
| Excellent | 11.0 | 19.4 | 10.1 | 26.4 | 14.8 |
| Maternal health attitude score tertiles | | | | | |
| Poor | 47.4 | 23.9 | 41.2 | 25.5 | 36.7 |
| Medium | 27.0 | 32.6 | 30.6 | 27.1 | 29.6 |
| Good | 25.5 | 43.5 | 28.2 | 47.4 | 33.7 |
| Attended at least 4 ANC visits | – | – | 36.2 | 68.9 | 45.5 |
| Had any pregnancy/delivery problem | – | – | 17.4 | 24.5 | 19.4 |
| Well prepared for the birth of the baby | – | – | 6.9 | 29.4 | 13.4 |
| Final decider on delivery place | | | | | |
| Woman alone | – | – | 48.3 | 23.1 | 41.1 |
| Partner/other family member alone | – | – | 34.0 | 60.3 | 41.5 |
| Woman and partner together | | | 17.7 | 16.6 | 17.4 |

recommended number of ANC visits and 23.3 % could mention at least three danger signs of pregnancy. About 42.4 % stayed more than one hour from a health facility providing delivery service. Only 14.8 % perceived the quality of maternal health services at their nearest facility to be excellent; and 13.4 % were well prepared for delivery.

### Determinants of antenatal care use

Results of the analysis of determinants of ANC use are presented in Table 2. In unadjusted analysis, only district, ethnicity, marital status and religion were not statistically significantly associated with ANC attendance. After adjusting for confounding factors, wealth index quintile, age, knowledge of the required number of ANC visits and maternal health attitude score maintained statistically significant associations with attending ANC. Wealth index and knowledge of the required number of ANC visits had the strongest associations with ANC attendance. Women in the highest wealth quintile had a three and a half fold increase in the odds of attending ANC compared to those in the lowest wealth quintile (OR 3.53, 95 % CI 1.69–7.39), and those who knew the recommended number of ANC visits had almost a threefold increase in the odds of attending ANC compared to those who did not know (OR 2.75, 95 % CI 1.89–4.01). The odds of attending ANC reduced with increasing age. Women with a good attitude towards maternal health were about twice more likely to attend ANC compared to those with a poor attitude (OR 2.20, 95 % CI 1.22–3.98).

### Determinants of skilled birth attendant at delivery

Table 3 presents the results of the analysis of determinants of delivery with a SBA. In unadjusted analysis only district, ethnicity, marital status, religion or having a pregnancy/delivery related problem were not significantly associated with delivery by a SBA. After controlling for other factors, compared to rural dwellers, urban dwellers were more likely to deliver assisted by a SBA (OR 7.31, 95 % CI 2.88–18.55). Wealth index was positively associated with delivery by a SBA with women in the highest wealth quintile having a 9-fold increase in the odds of delivery by a SBA compared to those in the lowest wealth quintile (OR 8.94, 95 % CI 2.45–32.61). The odds of delivery by a SBA decreased with increasing parity and time to the nearest health facility. Unmarried women were less likely to deliver assisted by a SBA. Knowledge of the required ANC visits (OR 2.65, 95 % CI 1.47–4.76) and experience of a pregnancy/delivery problem (OR 2. 94, 95 % CI 1.31–6.61) were positively associated with delivery by a SBA. Women with an excellent perception about the quality of maternal health care at the nearest health facility were more likely to deliver assisted by a SBA compared to those who perceived the quality to be poor/average (OR 6.45, 95 % CI

**Table 2** Odds ratios for the association between various factors and attendance of four ANC visits

| Characteristics | Unadjusted OR (95 % CI) | *P* value[i] | Adjusted OR[a] (95 % CI) | *P* value[i] |
|---|---|---|---|---|
| District | | 0.820 | | |
| Wolisso | 1 | | – | |
| Goro | 1.08 (0.58–2.01) | | – | |
| Wonchi | 0.89 (0.47–1.69) | | – | |
| Urban residence | 3.69 (2.21–6.17) | <0.001 | 1.62 (0.84–3.14) | 0.145 |
| Non Oromo ethnicity | 1.79 (0.98–3.26) | 0.058 | 1.41 (0.78–2.54) | 0.241 |
| Household size | | 0.017 | | 0.867 |
| 2–3 | 2.04 (1.29–3.25) | | 1.14 (0.66–1.94) | |
| 4–5 | 1.43 (0.91–2.24) | | 1.16 (0.61–2.21) | |
| >5 | 1 | | 1 | |
| Wealth index quintile | | 0.001 | | 0.015 |
| Lowest | 1 | | 1 | |
| Second | 2.44 (1.45–4.11) | | 2.29 (1.27–4.15) | |
| Middle | 1.46 (0.75–2.85) | | 1.10 (0.50–2.41) | |
| Fourth | 2.59 (1.50–4.47) | | 1.96 (1.04–3.68) | |
| Highest | 5.74 (2.90–11.36) | | 3.53 (1.69–7.39) | |
| Age in years | | 0.001 | | 0.003 |
| 15–24 | 1 | | 1 | |
| 25–29 | 0.78 (0.50–1.21) | | 0.81 (0.47–1.38) | |
| 30–34 | 0.43 (0.27–0.69) | | 0.37 (0.21–0.66) | |
| 35–49 | 0.39 (0.24–0.64) | | 0.42 (0.25–0.72) | |
| Parity | | 0.030 | | 0.936 |
| 1 | 1 | | 1 | |
| 2–3 | 0.69 (0.42–1.13) | | 0.98 (0.54–1.76) | |
| 4–5 | 0.58 (0.36–0.96) | | 1.07 (0.49–2.31) | |
| >5 | 0.37 (0.20–0.67) | | 0.89 (0.352.31) | |
| Woman's education level | | 0.003 | | 0.313 |
| None | 1 | | 1 | |
| Primary | 1.65 (1.07–2.56) | | 1.00 (0.56–1.76) | |
| Secondary/higher | 3.01 (1.70–5.33) | | 0.74 (0.40–1.35) | |
| Partner's education level | | 0.015 | | 0.770 |
| None/no partner | 1 | | 1 | |
| Primary | 1.49 (0.86–2.59) | | 0.95 (0.49–1.84) | |
| Secondary/higher | 2.48 (1.33–4.62) | | 0.80 (0.34–1.86) | |
| Marital status | | 0.514 | | |
| Married | 1 | | – | |
| Single | 0.72 (0.26–1.99) | | – | |
| Religion | | 0.566 | | |
| Orthodox Christian | 1 | | – | |
| Protestant | 1.27 (0.80–2.03) | | – | |
| Muslim | 1.16 (0.71–1.87) | | – | |
| Knows number of required ANC visits | 3.53 (2.40–5.18) | <0.001 | 2.75 (1.89–4.01) | <0.001 |
| Knows ≥3 pregnancy danger signs | 1.61 (1.04–2.49) | 0.032 | 0.90 (0.60–1.35) | 0.605 |

**Table 2** Odds ratios for the association between various factors and attendance of four ANC visits *(Continued)*

| | | | | |
|---|---|---|---|---|
| Time to nearest facility | | 0.013 | | 0.367 |
| <30 min | 1 | | 1 | |
| 30–59 min | 0.55 (0.29–1.03) | | 0.63 (0.31–1.29) | |
| ≥60 min | 0.37 (0.20–0 .69) | | 0.64 (0.32–1.29) | |
| Perceived quality of care at nearest facility | | 0.035 | | 0.220 |
| Average/poor/don't know | 1 | | 1 | |
| Good | 1.34 (0.81–2.21) | | 1.46 (0.93–2.31) | |
| Excellent | 2.28 (1.21–4.31) | | 1.72 (0.85–3.48) | |
| Maternal health attitude score tertiles | | <0.001 | | 0.033 |
| Poor | 1 | | 1 | |
| Medium | 2.39 (1.54–3.69) | | 1.88 (1.11–3.18) | |
| Good | 3.37 (1.93–5.86) | | 2.20 (1.22–3.98) | |

[i]Adjusted Wald test *P*-value for the overall significance of the variable in the model
[a]adjusted for residence, knowledge of number of ANC visits, woman's age wealth index quintile and maternal health attitude score

2.77–15.01). Women who decided together with their husbands on delivery place had a 4-fold increase in the odds of delivery by a SBA than those who decided unilaterally. Women who were well prepared for the birth of the baby were more likely to deliver assisted by a SBA compared with those that were not well prepared (OR 4.71, 95 % CI 1.68–13.18).

## Discussion

In this study, attendance of at least four ANC visits was positively associated with wealth status, knowledge of the recommended ANC visits, and attitude towards maternal health care, but negatively associated with woman's age. Delivery by a SBA was negatively associated with parity and time to the nearest health facility but was positively associated with urban residence, wealth, knowledge of the required number of ANC visits, having a better perception towards the quality of maternal health services, experience of a pregnancy/delivery related problem, and birth preparedness. Additionally, involvement of the partner/family in decision making on delivery place increased the likelihood of SBA at delivery but being unmarried reduced this likelihood. The higher coverages of at least four ANC visits (45.5 %) and SBA at delivery (28.6 %) in this study compared to the corresponding national averages of (19.1 and 10 %, respectively) may be partly because of the external donor support that the study districts have been receiving in the past years.

The findings that poverty and higher age are associated with reduced ANC attendance are consistent with those of a systematic review of 28 studies on determinants of ANC use [28] and can be interpreted as if women with previous pregnancy and birth experience don't feel the need to go again through ANC for a new pregnancy. The present study however did not find significant associations between ANC attendance and many other socio-demographic factors as has been reported in other studies [14, 19, 28]. These studies looked at attendance of any ANC visit and not four or more ANC visits. Nevertheless, the discrepancies suggest that determinants of service access may vary by geographic location even within a country, and highlight the need to understand key determinants of service access in a given context in order to tailor intervention strategies [29]. Distance is a major determinant in the decision to seek care [30]. Although the Ethiopian government has recently tried to improve geographical accessibility in the study districts by building new HCs and opening new roads, 42 % of participants were staying more the 1 h from the nearest health facility, and utilisation of SBA, but not ANC, was being influenced by distance. This is because a woman in labour has little time within which to go to the hospital compared to woman an antenatal woman, and a usual walking distance may be unsurmountable for a woman in labour. Additionally, ANC but not SBA can be provided through outreach; reducing the geographical barrier. Knowledge of the recommended number of ANC visits was associated with increased use of ANC but knowledge of at least three pregnancy danger signs did not have significant effect on ANC attendance. Although both questions were meant to measure knowledge, the later might have been less specific; explaining the discrepancy. Although knowledge of safe motherhood practices such as danger signs of pregnancy may promote safer pregnancies and deliveries, few women knew at least 3 pregnancy danger signs; consistent with results previously reported [31, 32].

In line with results from previous studies in the same setting [33, 34], this study confirms the existence of two major dimensions of inequity in utilisation of SBA in the

**Table 3** Odds ratios for the association between various factors and delivery by a skilled provider

| Characteristics | Unadjusted OR (95 % CI) | *P* value[i] | Adjusted OR[a] (95 % CI) | *P* value[i] |
|---|---|---|---|---|
| District | | 0.554 | | |
| Wolisso | 1 | | – | |
| Goro | 0.91 (0.26–3.13) | | – | |
| Wonchi | 0.51 (0.14–1.81) | | – | |
| Urban residence | 32.80 (12.40–86.74) | <0.001 | 7.31 (2.88–18.55) | <0.001 |
| Non Oromo ethnicity | 2.42 (0.62–9.49) | 0.195 | – | |
| Household size | | <0.001 | | 0.939 |
| 2–3 | 4.63 (2.77–7.75) | | 0.79 (0.15–4.10) | |
| 4–5 | 1.60 (1.04–2.48) | | 0.79 (0.15–4.10) | |
| >5 | 1 | | 1 | |
| Wealth index quintile | | <0.001 | | 0.004 |
| Lowest | 1 | | 1 | |
| Second | 1.54 (0.68–3.53) | | 0.76 (0.36–1.61) | |
| Middle | 1.55 (0.67–3.61) | | 0.69 (0.19–2.49) | |
| Fourth | 6.00 (2.63–13.69) | | 3.47 (1.46–8.25) | |
| Highest | 27.46 (8.48–88.89) | | 8.94 (2.45–32.61) | |
| Age in years | | 0.026 | | 0.262 |
| 15–24 | 1 | | 1 | |
| 25–29 | 0.57 (0.37–0.87) | | 0.60 (0.28–1.27) | |
| 30–34 | 0.56 (0.37–0.86) | | 0.54 (0.30–0.99) | |
| 35–49 | 0.50 (0.26–0.96) | | 0.61 (0.27–1.38) | |
| Parity | | <0.001 | | 0.003 |
| 1 | 1 | | 1 | |
| 2–3 | 0.34 (0.20–0.58) | | 0.30 (0.10–0.90) | |
| 4–5 | 0.17 (0.10–0.28) | | 0.17 (0.06–0.44) | |
| >5 | 0.20 (0.09–0.45) | | 0.21 (0.07–0.66) | |
| Woman's education level | | <0.001 | | 0.241 |
| None | 1 | | 1 | |
| Primary | 2.33 (1.47–3.70) | | 0.52 (0.24–1.11) | |
| Secondary/higher | 9.27 (3.01–28.48) | | 0.66 (0.19–2.22) | |
| Partner's education level | | <0.001 | | 0.468 |
| None/no partner | 1 | | 1 | |
| Primary | 2.49 (1.51–4.46) | | 0.67 (0.36–1.26) | |
| Secondary/higher | 10.37 (5.16–20.85) | | 0.63 (0.25–1.60) | |
| Marital status | | 0.079 | | 0.034 |
| Married | 1 | | 1 | |
| Single | 0.39 (0.13–1.13) | | 0.22 (0.06–0.87) | |
| Religion | | 0.804 | | |
| Orthodox Christian | 1 | | – | |
| Protestant | 1.30 (0.58–2.91) | | – | |
| Muslim | 1.05 (0.40–2.76) | | – | |
| Knows required number of ANC visits | 2.74 (1.85–4.05) | <0.001 | 2.65 (1.47–4.76) | 0.002 |
| Knows ≥3 pregnancy danger signs | 2.08 (1.16–3.75) | 0.016 | 0.67 (0.30–1.52) | 0.322 |
| Time to nearest facility with maternity | | 0.001 | | 0.023 |

**Table 3** Odds ratios for the association between various factors and delivery by a skilled provider *(Continued)*

| | | | | |
|---|---|---|---|---|
| <30 min | 1 | | 1 | |
| 30–59 min | 0.22 (0.10–0.45) | | 0.48 (0.23–0.96) | |
| ≥60 min | 0.14 (0.05–0.37) | | 0.35 (0.15–0.82) | |
| Perceived quality of care at nearest facility | | 0.002 | | <0.001 |
| Average/poor/don't know | 1 | | 1 | |
| Good | 1.36 (0.81–2.31) | | 1.73 (0.87–3.47) | |
| Excellent | 3.77 (1.89–7.49) | | 6.45 (2.77–15.01) | |
| Maternal health attitude score tertiles | | 0.004 | | 0.104 |
| Poor | 1 | | 1 | |
| Medium | 1.43 (0.81–2.53) | | 0.50 (0.24–1.01) | |
| Good | 2.72 (1.58–4.66) | | 0.61 (0.31–1.25) | |
| Attended at least 4 ANC visits | 3.91 (2.57–5.94) | <0.001 | 1.41 (0.93–2.17) | 0. 105 |
| Had a pregnancy/delivery related problem | 1.54 (0.92–2.60) | 0.090 | 2.94 (1.31–6.61) | 0.011 |
| Final decision maker on delivery place | | <0.001 | | 0.002 |
| Woman alone | 1 | | 1 | |
| Partner/other family member alone | 1.97 (1.02–3.79) | | 4.76 (2.16–10.47) | |
| Woman and partner together | 3.71 (2.45–5.63) | | 3.92 (1.64–9.36) | |
| Well prepared for delivery of baby | 5.59 (2.42–12.85) | <0.001 | 4.71 (1.68–13.18) | 0.005 |

[i]Adjusted Wald test *P*-value for the overall significance of the variable in the model
[a]adjusted for residence, partners education level, decider on place of delivery, attended 4 ANC visits, parity, wealth quintile, perceived quality of care at nearest facility, birth preparedness, marital status, had pregnancy/delivery problem, knowledge of the required number of ANC visits and time to the nearest health facility. Due to collinearity between age and parity, the final model excluded age; thus age is adjusted for all these variables except parity

study districts: rural/urban location and wealth [35]. Although persistent disparities exist between poorer and richer women regarding utilisation of maternal and child health services in low income countries, SBA at delivery is the most inequitable [36, 37]. In general, services delivered through fixed health facilities such SBA at birth tend to show greater disparities than those which can be delivered through outreach such as ANC [38]. As in other studies [39], this study found an inverse relationship between utilisation of SBA and parity and confirms the need to target women with higher parity in maternal health service provision. Although based on small numbers, unmarried women were less likely to utilise SBA compared to married women. This may be because it is culturally unacceptable for an unmarried woman to become pregnant in this setting [40], consequently, unmarried women may be shying away from utilising maternal health services. The present study did not find statistically significant association between use of delivery service and woman's age, woman's education and partner's education as has been reported elsewhere [39]. Our findings suggest that education is not a strong determinant of utilisation of maternal health services in this context where more than half of the women are uneducated.

Our study concurs with findings from other studies that have found that women are more likely to use delivery services if they experience pregnancy related problems [13, 14, 39, 41]. Women with complications in pregnancy may be referred by a TBA, other person assisting when the complication arose or even self-refer to health facilities. Unfortunately such referrals do not always happen on time and mothers/neonates have lost lives due to various delays [30]. In many resource-poor settings, ANC visits constitute one of the few times when women seek care presenting a critical opportunity for informing them about the importance of skilled delivery care. However, after accounting for other factors, attending at least four ANC visits was not associated with increased SBA at delivery in our study as has been reported elsewhere [42].

In the present study, women whose final decision on where to deliver was made in consultation with the partner or by a family member were more likely to be assisted by a SBA at delivery. Similar findings have been reported in a study conducted in the same region [13], and highlight the importance of family support in improving maternal health services utilisation. Although women's autonomy increases health service utilisation [43, 44], the role of family concern and support especially for SBA utilisation cannot be overlooked. On the other hand, studies have also shown the negative effect of too many people being involved in the decision making process leading to delays in seeking care [41], an

effect that does not seem to be applicable to this area of Ethiopia.

Having a birth plan increases the likelihood of delivering in a health facility [45]. Theoretically, this is mediated through reduction in delays in obtaining care [30]. Our findings that women who were well prepared for the delivery of the baby were more likely to be assisted by a SBA at delivery support the concept of birth preparedness and complication readiness during pregnancy. Unfortunately, in line with the present study, a worldwide systematic review [41] and studies in Ethiopia [46, 47] have found that few women are well prepared for birth and pregnancy complications. This problem is aggravated by poor knowledge and practices related to birth preparedness [47].

Perceived low quality of care is a major barrier to utilisation of maternal health services and can result into the first delay: delaying the decision to seek care [30, 41]. The findings in the present study are in line with this well documented barrier and highlight the need to simultaneously address both the demand and supply side barriers to improve service utilisation [48].

This survey has limitations that prevent the full understanding of the barriers and facilitators for ANC attendance and delivery assisted by SBA in the study area. It is not only the perceived quality of care provided at health facilities that is important. With the ultimate objective of improving maternal and newborn health, the real quality of the care, whether antenatal care includes evidence-based interventions and to what extent equipment, tests, medicines and other supplies are available are paramount. Transportation and direct or indirect costs were also not evaluated in this survey. Inadequate staffing potentially leading to long waiting time in receiving care at health facilities was also not studied here.

## Conclusions

This is the first study to assess determinants of use of two important interventions for reducing maternal and newborn mortality and morbidity during pregnancy and childbirth in Goro, Wolisso and Wonchi districts. The findings highlight the importance of raising awareness about ANC and emphasising the minimum recommended number of ANC visits. All pregnant women should be encouraged to have a birth and complication readiness plan. This could be done routinely during ANC visits and also through community mobilisation with the involvement of health extension workers. At the moment, the study districts have numerous HCs whose utilisation is still very low; only 27 % of women delivered in 16 HCs as compared to 69 % who delivered in the one hospital. There is a high potential of improving coverage of delivery by SBA in the study districts if HCs are strengthened to respond to the maternal health needs in the population. Apart from increasing coverage, improving service delivery at HCs will contribute towards reduced inequity. A recent study has found huge gaps in the availability of emergency obstetric care services at HCs [33]; further justifying the need for more support at this level. The problem of long distance to the health facility could be addressed through innovative solutions such as use of transport vouchers [49] or other transportation schemes, and construction of health centres in underserved areas. The important role of the family found in this survey highlights the need not only to mobilise women but also their husbands, families and the entire community. Pregnant women need the encouragement and support of family members in order to access delivery care service. Given that most women deliver at home assisted by TBAs, there is need for collaboration between the formal health system and TBAs with the aim of encouraging TBAs to refer pregnant women to deliver in health facilities.

## Additional file

**Additional file 1: Table: Post-hoc power calculations based on various variables for attendance of at least four antenatal care (ANC) visits and delivery by skilled birth attendant (SBA).** (DOCX 17 kb)

### Abbreviations

ANC: Antenatal care; CI: Confidence interval; CUAMM: *Collegio Universitario Aspiranti Medici Missionari*; HC: Health centre; JHPIEGO: Johns Hopkins Program for International Education in Gynaecology and Obstetrics; MMR: Maternal mortality ratio; OR: Odds ratio; SBA: Skilled birth attendant; TBA: Traditional birth attendant; UNICEF: United Nations Children's Fund.

### Competing interests

The authors declare that they have no competing interests.

### Authors' contributions

CW, GP, FC and DA conceived and designed the study. CW, FC and DA acquired data. CW and RT performed statistical analysis. CW, RT, GQ and APB drafted the initial manuscript. CW, RT, GQ, APB, GP, FC, DA, DDR and AA participated in interpreting the data and revising the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

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# How Can Childbirth Care for the Rural Poor Be Improved? A Contribution from Spatial Modelling in Rural Tanzania


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The use of spatial and geographic models such as Geographical Information Systems (GIS) was integrated into this study, whose aim was to assess the coverage of health care centers offering obstetric services in two rural areas of Tanzania, the Iringa and Ludewa Districts.

Both areas have a high density of health care facilities. However, the maternal and neonatal services they provide are inadequate; about half of the facilities do not have enough staff to guarantee full-time services and treatment. This means that in 48 facilities out of 70 in Iringa and 43 out of 52 in Ludewa, less than 100 assisted deliveries are provided annually.

At the same time, the availability of a good number of health care centers means that local populations can choose among them, with a preference for those that offer the broadest range of skilled services.

In this study the use of multiple and integrated spatial and geographic models made it possible to calculate the distances that local populations would have to travel if some of the health care centers were eliminated. Based on a hypothetical maximum walking distance of 2 hours, it was found that the number of facilities could be reduced by 40%, thereby freeing up resources that could then be reallocated to the remaining facilities in order to improve their performances. In such a scenario, only 7% of the population would live more than 2 hours' walking distance from the nearest health care center. Thus there would be less coverage than before, but also a probable marked improvement in the quality of the services delivered.

PLOS ONE

RESEARCH ARTICLE

# How Can Childbirth Care for the Rural Poor Be Improved? A Contribution from Spatial Modelling in Rural Tanzania

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## Abstract

### Introduction

Maternal and perinatal mortality remain a challenge in resource-limited countries, particularly among the rural poor. To save lives at birth health facility delivery is recommended. However, increasing coverage of institutional deliveries may not translate into mortality reduction if shortage of qualified staff and lack of enabling working conditions affect quality of services. In Tanzania childbirth care is available in all facilities; yet maternal and newborn mortality are high. The study aimed to assess in a high facility density rural context whether a health system organization with fewer delivery sites is feasible in terms of population access.

### Methods

Data on health facilities' location, staffing and delivery caseload were examined in Ludewa and Iringa Districts, Southern Tanzania. Geospatial raster and network analysis were performed to estimate access to obstetric services in walking time. The present geographical accessibility was compared to a theoretical scenario with a 40% reduction of delivery sites.

### Results

About half of first-line health facilities had insufficient staff to offer full-time obstetric services (45.7% in Iringa and 78.8% in Ludewa District). Yearly delivery caseload at first-line health facilities was low, with less than 100 deliveries in 48/70 and 43/52 facilities in Iringa and Ludewa District respectively. Wide geographical overlaps of facility catchment areas were observed. In Iringa 54% of the population was within 1-hour walking distance from the nearest facility and 87.8% within 2 hours, in Ludewa, the percentages were 39.9% and 82.3%. With a 40% reduction of delivery sites, approximately 80% of population will still be within 2 hours' walking time.

## Conclusions

Our findings from spatial modelling in a high facility density context indicate that reducing delivery sites by 40% will decrease population access within 2 hours by 7%. Focused efforts on fewer delivery sites might assist strengthening delivery services in resource-limited settings.

## Introduction

Maternal deaths worldwide remain a major public health issue, with 289 000 deaths from complications of pregnancy and delivery in 2013 [1]. More than half occur in sub-Saharan Africa, with the highest mortality ratios in rural areas and among poorer communities [2]. The picture of this tragedy is completed by newborn outcomes; about three million neonates die every year and an additional 2.6 million are stillborn [3]. Not unexpectedly maternal health and newborn health are closely linked and deaths are preventable if adequate and timely childbirth care is provided by skilled health personnel based in functioning health facilities [4].

Improving institutional delivery coverage is one strategy advocated to reduce deaths among the rural poor. Although proximity to health facility is strongly associated with higher facility births [5], the mere facility use for delivery does not translate into early neonatal or maternal mortality reduction [6]. Shorter distance to emergency obstetric and neonatal care is associated with lower early neonatal mortality only if high level of care is provided [7, 8]. In other words, mortality during childbirth depends on factors related to the quality of services offered, such as the 24 hours/7 days availability of qualified personnel supported by expertise, medical supplies, drugs and by a functioning referral system.

With a mortality rate of 454 per 100,000 live births in 2010, the United Republic of Tanzania is unlikely to meet the Millennium Development Goal target of 218 deaths for 100,000 live births by 2015 [9]. Tanzania is a low-resources country with a pyramidal-shaped health care system. First-line facilities, namely dispensaries and health centres are at the base offering primary level care and referral hospitals at the apex. Basic childbirth services are provided at all levels while obstetric interventions including surgery and blood transfusion are generally only available in district or higher level hospitals [10]. To improve population coverage an increased number of first-line facilities is planned [11] and to reduce maternal, newborn mortality and morbidity the majority of first-line facilities are set to provide basic emergency obstetric and neonatal care [12, 13]. Obstetric services are classified according to the level of care provided to treat obstetric complications in Basic Emergency Obstetric Care (BEmOC) and Comprehensive Emergency Obstetric Care (CEmOC). To qualify as BEmOC health facilities have to regularly perform seven signal functions (administration of parental antibiotics, uterotonic drugs, and anticonvulsants, manual removal of placenta, removal of retained products, assisted vaginal deliveries, and neonatal resuscitation) whereas CEmOC carry out also caesarean sections and blood transfusions [14].

Poorly equipped, understaffed first-line health facilities with low delivery caseload have been described in rural Tanzania and are considered a major barrier to quality childbirth care [15–18]. Rural poor are disadvantaged in accessing quality services compared to wealthier women as they are less likely to bypass first-line facilities to deliver at high volume and high quality hospital level [18, 19]. Recent studies have suggested that in a scenario of increasing health facility density and persisting limited resources, childbirth care for the rural population could be improved by concentrating available resources in fewer delivery sites without modifying facilities numbers [18,

19]. Delivery sites should have good geographical accessibility and be adequately equipped and staffed to provide maternal services 24h/7d, while remaining first-line health facilities would continue to provide other preventive and curative services. The question that arises is whether delivery site reduction may compromise population accessibility.

In an attempt to define a health system reorganization with delivery sites, factors as geographical accessibility, population density, transport and means of communication must be taken into consideration. Although distance has been traditionally used as a measure of physical accessibility, travel time to reach BEmOC facilities has become a more accurate indicator for monitoring maternal mortality reduction interventions, especially in rural areas where lack of transport and geographical barriers might delay access to life-saving services. A maximum of two hours' travel time has been indicated to reach BEmOC services [20]. This is the time available to treat haemorrhage, the most rapidly fatal complication of pregnancy, and basic obstetric services should be accessible to the majority of women within this time span [21].

Geographical Information System (GIS) technology and spatial modelling can play a key role in public health, particularly in assessing physical access to health services and planning resource allocation [22, 23]. The application of raster and network methods for estimating distance and travel time in health services research has been extensively described [24]. Raster methods are mostly used for rural areas with limited infrastructure while network methods are suitable for urban settings with road-connected health facilities. Spatial analysis based on network methods is considered more accurate than raster methods as it relies on existing paths rather than Euclidean distances [25].

The study aimed to assess whether a health system organization with fewer delivery sites is possible in terms of population access within 2 hours' walking time. We carried out the research in a rural context in Southern Tanzania characterized by a high coverage of institutional deliveries, high health facility density and limited infrastructure network [26]. We investigated whether and to what extend a reduction of delivery sites was feasible to allow access within 2 hours' travel time to about 80% of the population, in line with the Tanzania target of 80% skilled birth attendance (SBA) coverage by end 2015 [27]. To estimate walking time in rural areas we tested an innovative network-based approach and we compared it with a raster method for validation.

The findings from this study will provide a new perspective for policymakers on how to organize childbirth services in resource-limited settings.

## Methods

### Study area

This study was conducted in two rural districts, Iringa and Ludewa, formerly both part of Iringa Region, and presently in Iringa and Njombe Regions (Fig 1), characterised by high maternal services uptake. According to the latest National Demographic Health Survey the regional estimates for antenatal care coverage (at least one visit) and institutional deliveries were respectively 97.3% and 80.4% [26].

Iringa District has a habitable surface of 9857 $Km^2$ and is morphologically and climatically divided into three areas: the Highlands (over 2000 m asl) located in the south-west, the Midlands in the north-east and the Lowlands in the north-west, the latter being extensively covered by a national park and mostly uninhabited. According to the national census the population in 2012 was 254,023, with 85% relying on subsistence farming. The total number of villages was 122 and the road network consisted of 1272 km of tarmac and unpaved roads [28]. Health services in 2012 were available in 72 facilities, of which 65 dispensaries, 6 health centres and one diocesan District-designated hospital. The majority of health facilities were public, with only

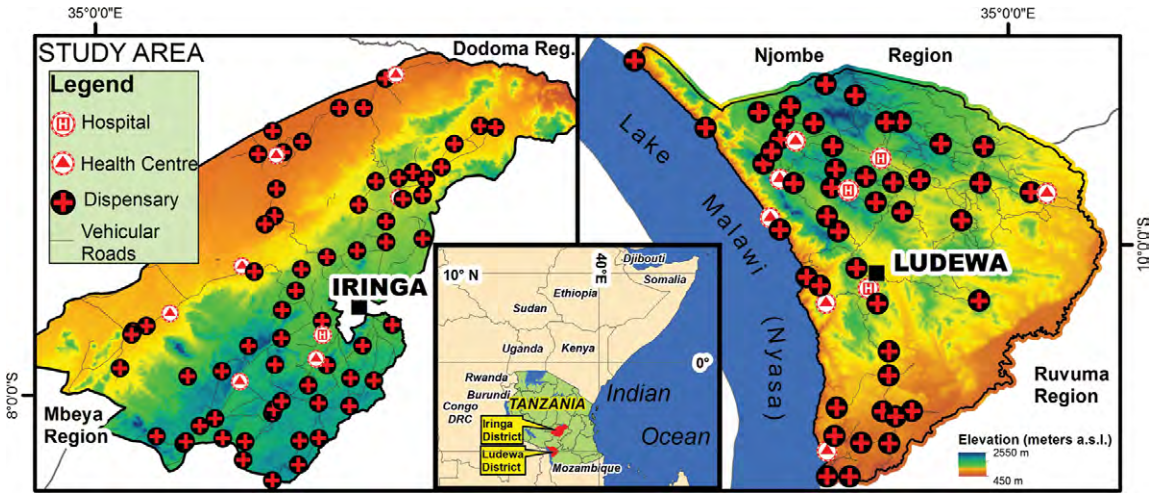


**Fig 1. Location map of Ludewa and Iringa Districts.**

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27% run by private non-profit organizations. Delivery services were provided by all health facilities except one dispensary located in Ruaha National Park.

Ludewa District is part of Njombe Region and borders Lake Malawi. It has a population of 133,218 and a habitable surface of 6012 $Km^2$. The district is predominantly rural with 77 villages and a road network of 970 Km. People derive their livelihood from subsistence farming, fishing, mining and small scale trading [29]. Morphologically Ludewa District is represented in the north-west by a mountainous and rainy area (Livingstone Mountains with an average elevation of over 2000 m asl), in the centre by a midland area with high population density and in the south by a lowland area, mostly flat and fertile near the Ruhuhu river. Health services in 2012 were provided by 55 facilities, of which 46 dispensaries, 6 health centres and 3 hospitals. 20% (11/55) of health facilities were run by private non-profit organizations.

Both districts are characterised by limited road infrastructure and scarce transport services.

## Field data collection

Data on 2012 staffing and health facility deliveries were obtained at district level from the Human Resources Information System and Health Management Information System and were validated during site visits by comparing routinely collected data with local registers. The Iringa District data were part of a larger dataset described in a previous study [18]. Clinicians, enrolled and registered nurses were categorized as skilled birth attendants while nursing assistant were not, according to the health system organization in Tanzania [17]. The lists of villages and existing health facilities were obtained from District Land Offices and District Medical Offices. Geographical data on location of health facilities were collected during site visits from April to August 2013. A waypoint was marked at the main entrance of each facility by using hand-held Global Position System units (Garmin Etrex 10, Nokia E5-00SE) or an USB GPS device connected to a laptop. Longitude and Latitude data were recorded with an accuracy of 5–15 metres in WGS 1984 Datum coordinate system and were converted in WGS_1984_UTM_Zone_36 system.

Geographical coordinates were recorded for all health facilities (55) of Ludewa District, and for 71 out of 72 of Iringa District. As mentioned before, data was not collected from one dispensary that does not provide delivery services.

In Ludewa District more than 650 km of motorable roads and 24 km of footpaths were recorded with the track function of Garmin Etrex GPS respectively by car transport and walking.

## Sources and processing of geographical data

Topographic sheets with scale 1:50000 of United Republic of Tanzania (completed between 1977 and 1982) were used as source of data for villages, watercourses, lakes, roads, tracks and footpaths. Road network and location of villages were updated using remote sensing by comparison of available topographic data with Bing™ and Google Earth™ satellite images. Free online datasets on district boundaries, main road network, main cities, main river network and land use were downloaded from FAO GeoNetwork [30]. A 90 metres cell Digital Elevation Model (DEM) was acquired by US Geological Survey (DEM courtesy of the U.S. Geological Survey) [31] and was used to create the slope and aspect maps. Geographical and administrative data were processed with ArcGIS 10.2™ software (ESRI, Redlands, CA).

## Estimating travel speed

The road network of each district was classified into 5 classes according to road size, type of surface and seasonal condition (Table 1). Road classification was carried out by merging information gathered through Google Earth™ and Bing™ satellite images with 1:50000 maps and data collected in the field. Walking speeds were recorded through a sample walk of 24 km across a morphologically representative area. Data were collected using a healthy male volunteer with a portable GPS. The recorded track log was split into 10% slope intervals and walking speeds were tabulated for each category of slope. The findings from our study were compared with previous published data [32–34]. Despite a similar trend in speed reduction by degree of surface inclination, absolute values were different from those estimated by other authors (Table 2). It was therefore decided to adopt the more conventional Naismith-Langmuir Rule to estimate walking speed for the study population composed mainly of pregnant women (Table 2) [34].

Vehicular travel time was calculated by applying to each type of road a set of travel speeds as described by other authors (Table 1) [25, 35].

## Population data

Raster datasets on population distribution and population density were obtained from Worldpop Project [36]. Population data for Ludewa and Iringa Districts were updated by applying an adjustment factor to the Worldpop 2010 database based on the 2012 National Census Data [37] without changing the spatial distribution of the population. Data on population density were matched to each spatial model to estimate the percentage of population living in the two-hours' catchment area.

**Table 1. Road types and travel speeds by motorized and pedestrian transport.**

| Road Type | Speed km/h |
|---|---|
| Tarmac | 75 |
| Loose Surface | 45 |
| Dry Wheater | 40 |
| Motorable | 20 |
| On Foot | 4 |

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**Table 2. Walking speeds (slope in percent %).**

| Slope % | Measured Walking Speed (Km/h) | Naismith-Langmuir Rule Speed (Km/h) |
|---|---|---|
| < (-)100% | 0.61 | 0.61 |
| (-) 90–100% | 0.68 | 1.28 |
| (-) 80–90% | 0.74 | 1.38 |
| (-) 70–80% | 0.98 | 1.49 |
| (-) 60–70% | 1.51 | 1.63 |
| (-) 50–60% | 2.02 | 1.79 |
| (-) 40–50% | 2.54 | 1.99 |
| (-) 30–40% | 3.31 | 2.24 |
| (-) 20–30% | 3.65 | 3.03 |
| (-) 10–20% | 3.82 | 6.16 |
| (-) 0–10% | 3.98 | 4.30 |
| 0% | 3.78 | 4.00 |
| 0–10% | 3.64 | 2.99 |
| 10–20% | 3.51 | 1.98 |
| 20–30% | 3.36 | 1.49 |
| 30–40% | 3.03 | 1.19 |
| 40–50% | 2.72 | 0.99 |
| 50–60% | 2.40 | 0.85 |
| 60–70% | 2.27 | 0.75 |
| 70–80% | 2.14 | 0.66 |
| 80–90% | 2.09 | 0.60 |
| 90–100% | 2.03 | 0.54 |
| >100% | 1.03 | 0.24 |

The Langmuir Rule (1984) assumes a basal speed of 4 km/h and modifies the value according to the following conditions: increased travel time by 0.1 min per 1 m in ascent; reduced travel time by about 0.03 min per 1 m in descent, in the range of slope from -5°: to-12°; increased travel time by about 0.03 min per 1 m in descent for slope steeper than 12° (Noor A.M. et al., 2006).

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## Software

Data management and analysis were performed with ArcGIS™ 10.2 for Desktop (ESRI™), and Python scripts compiled by the authors. Raster and network analysis were carried out with ArcGIS™ extensions 3D Analyst, Network Analyst and Spatial Analyst. Geographical conversions and transformations from and to WGS_1984_UTM_Zone_36S (WKID: 32736 Authority: EPSG) were executed by the project tool supplied by ArcGIS™. Topological functions were used to check the consistency and coherence of line data sets. Minor calculations and ancillary data were managed with MS Excel™ spreadsheet functions and Python scripts.

## Spatial analysis

Two spatial models, based respectively on raster and network analysis, were developed to estimate travel time to reach the nearest health facility. Facility catchment area within 2 hours' walking time was defined with both methods and respective findings were compared for validation. Scenarios with reduced number of delivery sites were described and assessed for population coverage. In addition exploratory network analysis was carried out to assess multimodal transport (pedestrian and vehicular).

**Table 3. Friction coefficients used to estimate walking time in slope and land use rasters.**

| Slope % | Coefficient | Dry Season | Coefficient | Wet Season | Coefficient |
|---|---|---|---|---|---|
| 0–20% | 0.98 | Open Areas | 0.95 | Open Areas | 1.00 |
| 20–40% | 1.00 | Bushy Areas | 1.00 | Bushy Areas | 1.05 |
| 40–60% | 1.20 | Forest Areas | 1.05 | Forest Areas | 1.10 |
| 60–80% | 1.04 | | | | |
| 80–100% | 1.06 | | | | |
| >100% | 1.08 | | | | |

Friction coefficients were applied to each raster cell to estimate the time needed to cross the cells on foot according to surface characteristics.

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**Raster approach.** In the raster method the study area was split into unit cells of 90 square meters, the same resolution used by the Digital Elevation Model. Cost raster maps were created by intersecting basic raster maps with slope and land use surface datasets. Time to cross on foot each cell was adjusted for surface inclination (ascendant or descendant), land use, topographic features and seasonal variation by applying friction coefficients to walking speeds (Table 2 and Table 3). Lakes and swamps were classified as non-passing areas.

Walking time towards health facilities was estimated with the Path Distance ArcGIS™ Tool by identifying the shortest distance to the nearest health facility. Total walking time was estimated by adding up the time needed to cross contiguous cells and by taking into consideration geographical obstacles and slow crossing areas.

Cost distance maps were built for two scenarios: one with all existing health facilities and one with a reduced number of facilities that could be accessible within two hours' travel time by approximately 80% of the population. Selection criteria for including health facilities in the second scenario were based on spatial aspects and population density.

The Path Distance Output Raster was matched with population data (AfriPop) to estimate the cumulative percentage of population living within subsequent 20 minutes' intervals of walking time. The 20 minutes' time interval was arbitrarily chosen to map consecutive catchment areas around each health facility to provide sufficient details at local level. To compare population coverage by different scenarios three levels of access to health facilities were considered: less than one hour, less than two hours and greater than 2 hours' walking time. These thresholds were based on previous studies [38, 39] and on general guidelines [21]. The analysis was performed with the function Zonal Statistic as table tool of ArcGIS™.

**Network approach.** In rural settings such as in Iringa and Ludewa Districts, where road infrastructure and vehicular transport is limited, the application of network-based methods is hampered by lack of sufficient digital data in vector form. To overcome this constraint we constructed a network based on a combination of real and virtual data. Existing road network was merged with a virtual hexagonal /triangular mesh of lines. The surface of Iringa and Ludewa Districts was divided into 342000 and 539000 hexagonal / triangular areas with side lengths up to 223 metres.

Each side is characterized by an attribute value of estimated travel time towards the health facilities, according to type of slope (ascendant or descendent) and mode of transport (pedestrian or vehicular). A similar technique was previously applied in urban areas of Dar es Salaam [40]. As validation, findings from network analysis were compared with data recorded during the sample walk. Route analysis methods were applied to the virtual network to draw the shortest track between the starting and ending point of the sample walk.

For each health facility catchment areas based on consecutive 20 minutes' walking time were built. Cumulative population coverage within the three levels of access was estimated with

a Zonal Static Tool matched with the Afripop Raster Database. A scenario with a reduced number of delivery sites was produced for pedestrian transport and was compared with the raster methods outputs for validation. An additional scenario for both pedestrian and vehicular transport (multimodal transport) was produced as an attempt to simulate travel patterns with motorised transportation.

## Ethical considerations

Data used in this study were either available as unrestricted sources in the public domain or provided with permission from local health authorities. Health information was extrapolated from routinely collected data in an aggregated form. No data was collected at individual level.

# Results

## Maternal health services

Delivery services in 2012 were provided by all levels of health facilities in Iringa and Ludewa Districts.

Data on 2012 institutional deliveries were available for 69/71 (97.2%) health facilities in Iringa District and for 48/55 (87.3%) in Ludewa District. Out of 7645 reported institutional deliveries of Iringa District, 2140 (28%) took place at the only hospital offering comprehensive emergency obstetric services (CEmOC), while in Ludewa District a total of 2808 deliveries out of 4089 (68.7%) reported institutional deliveries were carried out in the three hospitals of the district that provide CEmOC. Remaining institutional deliveries were scattered across first-line health facilities, respectively 5505 deliveries in 70 health facilities in Iringa and 1281 deliveries in 52 health facilities in Ludewa District. Yearly caseload was less than 100 deliveries in 48/70 (68.6%) first-line health facilities in Iringa District and 43/52 (82.7%) first-line health facilities in Ludewa District (Table 4). Median delivery caseload for first-line health facilities in Iringa District was 65 (range 2–277) and 22 (range 2–117) in Ludewa District.

Data on staffing were available for all health facilities that provide delivery services. We found that 2/64 (3.1%) dispensaries in Iringa District and 12/46 (26%) dispensaries in Ludewa District had no skilled birth attendants and about half of first-line health facilities were staffed with only one SBA, 30/70 (42.9%) in Iringa District and 29/52 (55.8%) in Ludewa District (Table 5).

## Geographical coverage of maternal services

**Raster approach.** Geographical coverage of health facilities in terms of walking time is displayed in Fig 2A and 2C. Various overlapping areas are detected among several health facilities, especially for walking distances between one and two hours.

**Table 4. Staffing level in first-line health facilities (dispensaries and health centres).** Iringa and Ludewa districts. 2012.

| *Number of skilled birth attendants* | *Iringa District health facilities* | | *Ludewa District health facilities* | |
|---|---|---|---|---|
| | *n* | *(%)* | *n* | *(%)* |
| 0 | 2 | (2.9) | 12 | (23.1) |
| 1 | 30 | (42.9) | 29 | (55.8) |
| ≥ 2 | 38 | (54.3) | 11 | (21.2) |
| Total | 70 | | 52 | |

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**Table 5. Delivery caseload in first-line health facilities (dispensaries and health centres).** Iringa and Ludewa districts. 2012.

| *Number of deliveries* | *Iringa District health facilities* | | *Ludewa District health facilities* | |
|---|---|---|---|---|
| | *n* | *(%)* | *n* | *(%)* |
| 0–49 | 21 | (30.0) | 41 | (78.8) |
| 50–99 | 27 | (38.6) | 2 | (3.8) |
| 100–199 | 17 | (24.3) | 2 | (3.8) |
| ≥ 200 | 3 | (4.3) | 0 | (0.0) |
| NA* | 2 | (2.9) | 7 | (13.5) |
| Total | 70 | | 52 | |

* NA: data not available.

doi:10.1371/journal.pone.0139460.t005

Travelling distances are summarized in Table 6. At present 88% and 82% of women in Iringa District and Ludewa District reside within 2 hours' walking time to a facility offering delivery care. A reduction of number of delivery sites from 71 to 42 (40.8% reduction) in Iringa District and from 55 to 35 (36.4% reduction) in Ludewa District would decrease by 7% the proportion of women living within two hours' travel time and only few areas of the districts, displayed as grey shaded in Fig 2B and 2D would face an increased access time beyond 2 hours.

**Network approach.** Findings from sample walk and network analysis are displayed in Fig 3. The route covered by the volunteer (white dashed) is partially overlapping with the trajectory traced on the virtual network by the application Route Analysis of ArcGIS™ (continuous blue line). Although in some areas shorter distances are automatically selected by the software, overall time to reach the nearest health facility is similar to that recorded by the volunteer (5 hours and 30 minutes estimated by the software versus 5 hours and 38 minutes recorded in the field). This can be explained by the more conventional walking speeds applied to the network analysis (Naismith-Langmuir Rule) compared to the walking pace of the enrolled walker. There is also evidence of validity for the multimodal transportation model. The software estimates the shortest travel time needed to reach health facilities by combining vehicular transport on motorable roads to pedestrian speeds on virtual network (Fig 3 red and dashed yellow lines).

After validation, network analysis was applied to both districts to define areas located within 2 hours' travel time from each health facility (Fig 4A and 4D). Several overlapping areas are observed at one hour walking time and above, as has already been highlighted with raster method. To minimize overlap across health facilities a scenario with a reduced number of delivery sites is reproduced both for pedestrian (Fig 4B and 4E) and for multimodal travel time (Fig 2C and 4F).

Concerning population coverage, again, results from network analysis (Table 7) are consistent with findings from raster methods (Table 6). Both approaches suggest that a substantial decrease of number of delivery sites translates into less than 10% reduction of population within 2 hours' walking time.

## Discussion

Our analysis indicates that about half of the first-line health facilities were inadequately staffed and had a yearly case load below 100 deliveries limiting their ability to provide quality delivery care. Reducing the number of delivery sites by 40%, taking into consideration geographical and demographical aspects, would lead to an increased access time beyond 2 hours for only 7% of

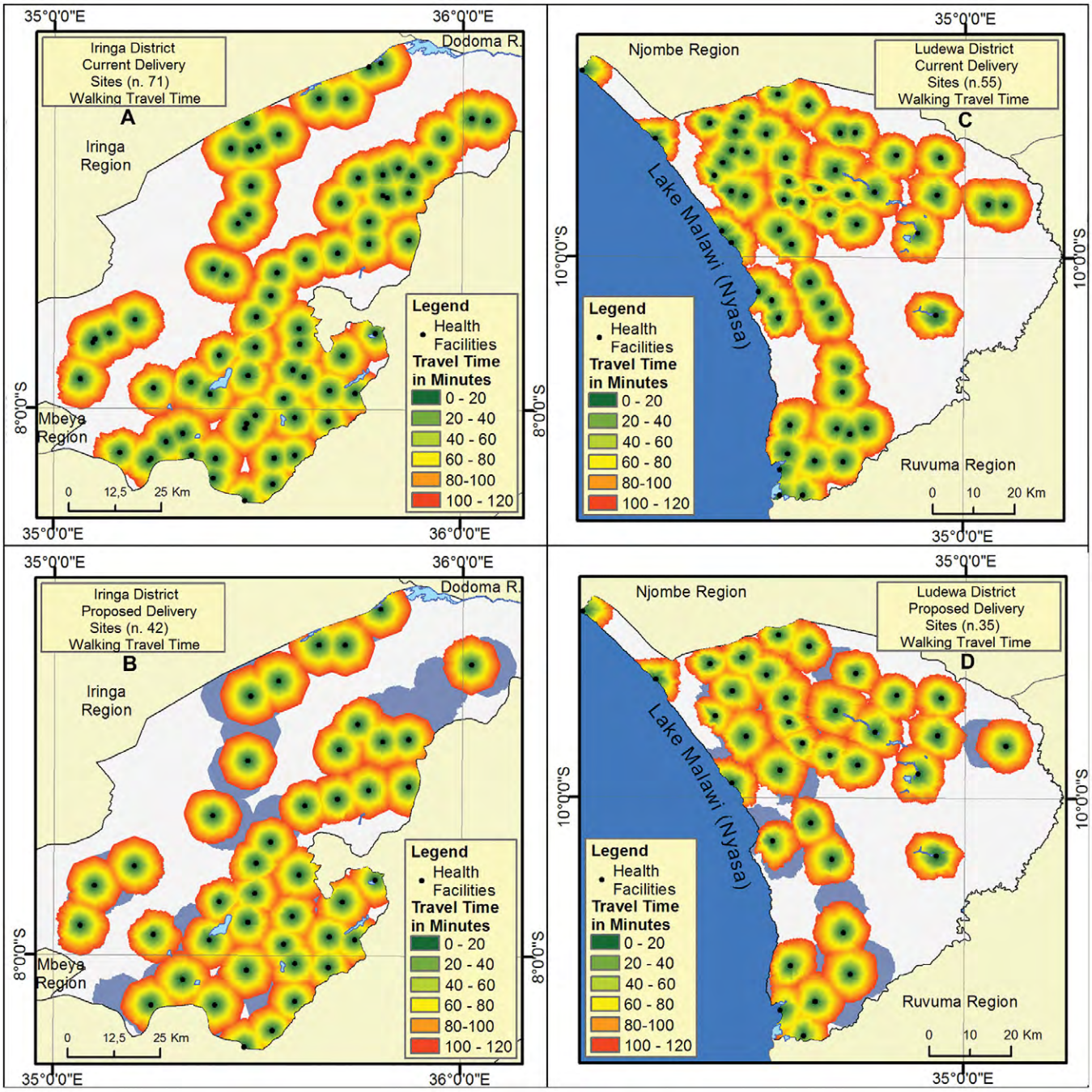


**Fig 2. Catchment area estimated by raster analysis.** The areas around health facilities represent a 2 hours' catchment divided in 20 minutes' intervals. (A) Iringa District current scenario with all delivery sites; (B) Iringa District proposed scenario with reduced number of delivery sites; (C) Ludewa District current scenario with all delivery sites; (D) Ludewa District proposed scenario with reduced number of delivery sites. The grey shades delimit the areas that will loose accessibility within 2 hours by a 40% reduction of delivery sites.

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population. To the best of our knowledge this is the first study on delivery services reorganization based on travel time in a rural context. A concentration of delivery sites could help to

**Table 6. Population coverage by walking distance to health facilities.** Present scenario and projections for reduced number of delivery sites. Raster analysis.

| Walking time | Population coverage (%) | | | |
|---|---|---|---|---|
| | *Iringa District* | | *Ludewa District* | |
| | Current delivery sites (N = 71) | Proposed delivery sites (N = 42) | Current delivery sites (N = 55) | Proposed delivery sites (N = 35) |
| ≤ 1 hour | 54.1 | 41.1 | 39.9 | 26.1 |
| ≤ 2 hours | 87.8 | 83.0 | 82.3 | 76.8 |
| > 2 hours | 12.2 | 17.0 | 17.7 | 23.2 |

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address the dilemma of accessibility and quality of care which resource poor settings face. The reduction of delivery sites would allow to concentrate skilled staff and obstetric services in higher volume settings with the aim of improving childbirth care, as recently recommended by other authors [18,19,41].

The investigated area is characterized by high health facility density and high institutional delivery coverage and offers therefore a paradigm to study the effects of an increased number of facilities on childbirth services' in resource-limited contexts. High geographical coverage was observed, with over 82% of population living within 2 hours' walking time from a health facility, yet half of first-line facilities were unable to provide skilled attendance at birth 24h 7 days/week due to low caseload and insufficient staff. Our findings are consistent with previous studies from rural Tanzania where a dilemma between high health facilities coverage and quality of obstetric services has been highlighted [17–19, 42, 43].

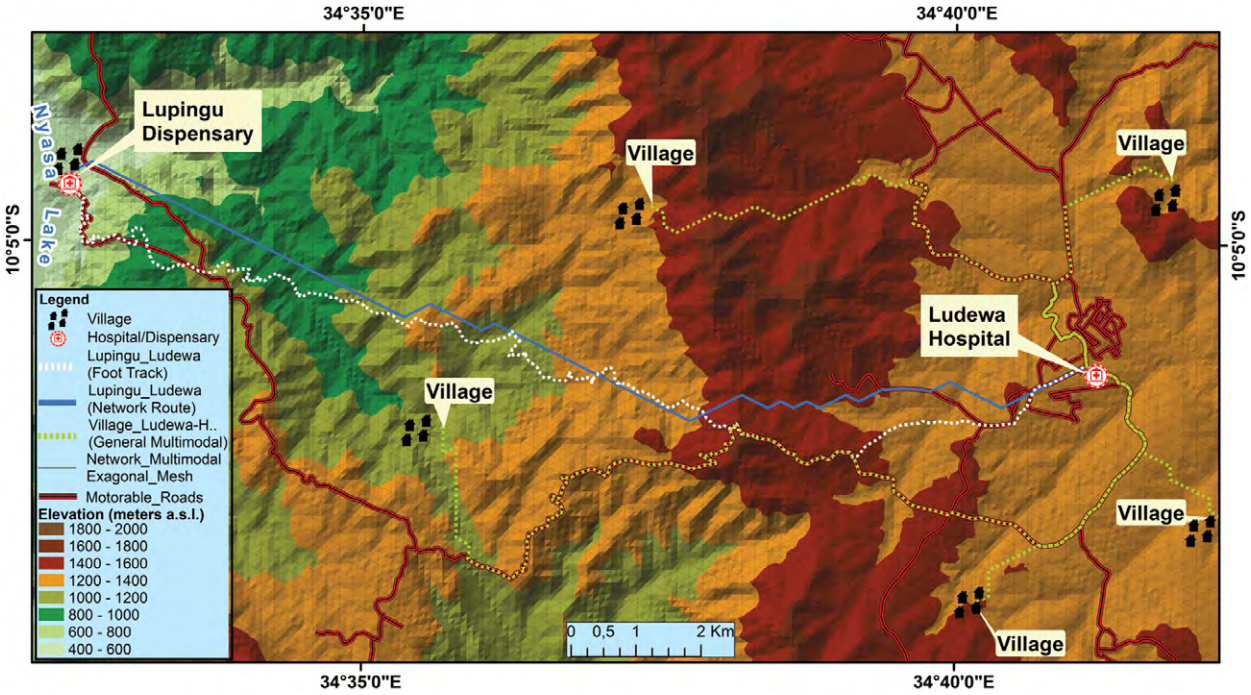


**Fig 3. Outputs from sample walk and network analysis.** The route covered by the volunteer (white dashed) corresponds to the trajectory traced by the software on the virtual network (blue line). Other tests are relative to four villages set at few kilometres away from motorable roads. The multimodal output (yellow dashed) automatically estimates the faster route to the hospital and is based both on virtual mesh lines and on existing motorable roads (red lines).

doi:10.1371/journal.pone.0139460.g003

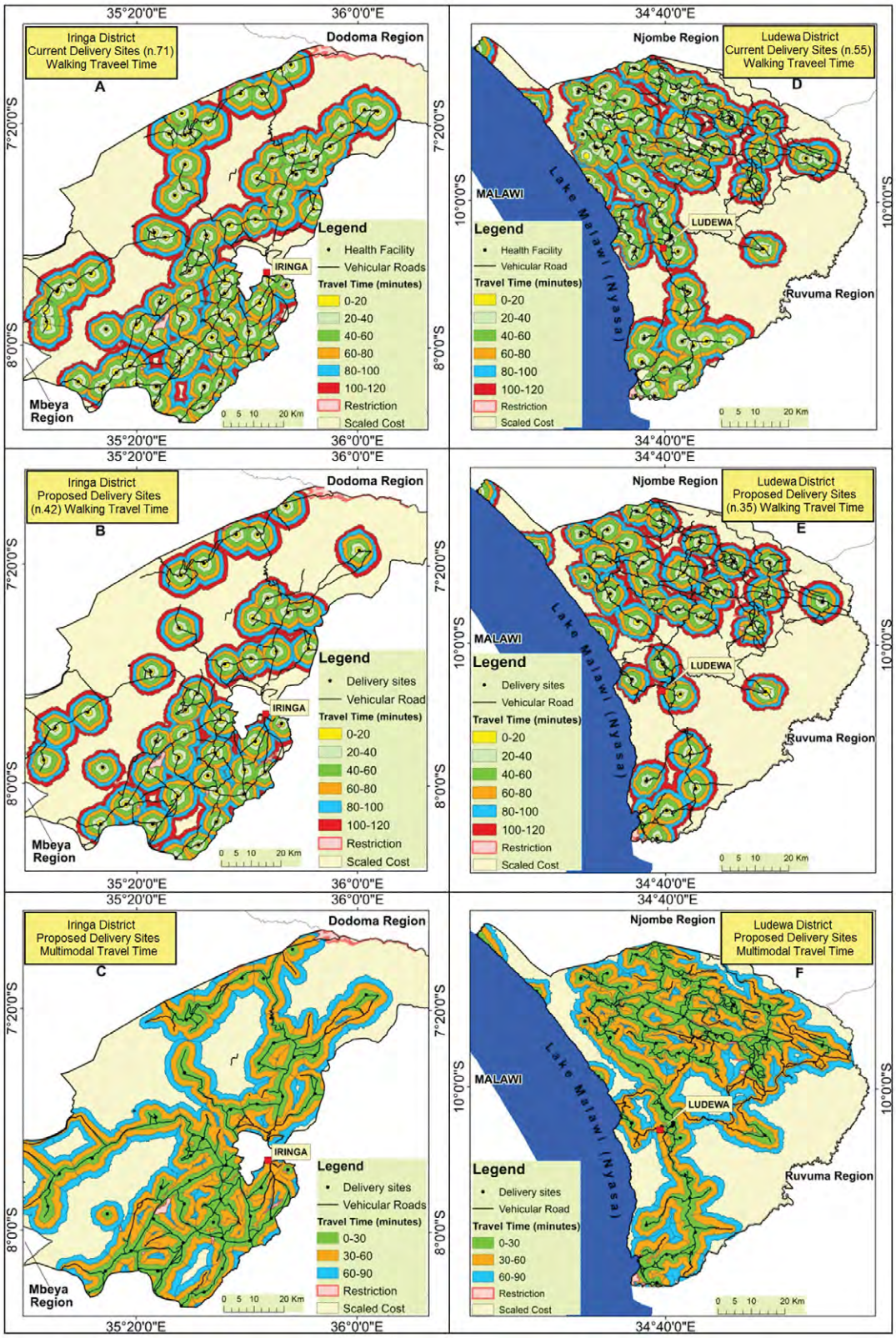
Iringa District
Current Delivery Sites (n.71)
Walking Traveel Time
A
Dodoma Region
IRINGA
Mbeya Region
Legend
Health Facility
Vehicular Roads
Travel Time (minutes)
0-20
20-40
40-60
60-80
80-100
100-120
Restriction
Scaled Cost
Njombe Region
Ludewa District
Current Delivery Sites (n.55)
Walking Traveel Time
D
MALAWI
Lake Malawi (Nyasa)
LUDEWA
Ruvuma Region
Legend
Health Facility
Vehicular Road
Travel Time (minutes)
0-20
20-40
40-60
60-80
80-100
100-120
Restriction
Scaled Cost
Iringa District
Proposed Delivery Sites
(n.42) Walking Travel Time
B
Legend
Delivery sites
Vehicular Road
Travel Time (minutes)
Ludewa District
Proposed Delivery Sites
(n.35) Walking Travel Time
E
Iringa District
Proposed Delivery Sites
Multimodal Travel Time
C
Legend
Delivery sites
Vehicular Roads
Travel Time (minutes)
0-30
30-60
60-90
Restriction
Scaled Cost
Ludewa District
Proposed Delivery Sites
Multimodal Travel Time
F
0 5 10 20 Km
35°20'0"E
36°0'0"E
34°40'0"E
7°20'0"S
8°0'0"S
10°0'0"S

**Fig 4. Catchment area estimated by network analysis.** The areas around health facilities represent a 2 hours' catchment divided in consecutive intervals for walking speed and for multimodal transport in Iringa and Ludewa Districts. (A, D) Current scenario with all delivery sites; (B, E) reduced number of delivery sites using walking speed; (C, F) reduced number of delivery sites using multimodal transport (vehicular and walking speed). Restriction: non-passing areas (lakes, swamps, etc.). Scaled cost: areas beyond 2 hours' travel time.

doi:10.1371/journal.pone.0139460.g004

## Reduced number of delivery sites

The distinction between access to a service site and access to effective case management is of paramount importance [44], particularly as densification of health facilities in resources limited settings is implemented.

Although shorter distance to point of care has been related to reduced under five child mortality in rural Tanzania, following improved access to immunization and to basic treatments [45–47], no association was found either between distance to health facility and early neonatal mortality [6] or between distance to any health facility and maternal mortality in similar rural contexts [48]. These apparently contrasting findings can be attributed to intrinsic differences between childbirth care and other preventive and curative interventions. The former requires functioning health facilities adequately equipped and staffed round the clock while other services do not require full time activity.

Poor staffing and low caseload in peripheral health facilities have already been described in rural settings [17, 18]. Our data suggest that in remote areas the picture is even more grim, with over a quarter of first-line health facilities not having any qualified staff and half having only one skilled birth attendant, who is unable to cover 24 hours shifts 7 days/week.

Policies aimed to improve population coverage by reducing distance might in fact affect the quality of services by diluting scarce resources. According to Tanzanian national policy, a further 3088 dispensaries, 2074 health centres and 19 district hospitals will be established by 2017 [11], meaning the number of first-line facilities will double over the next few years. As a consequence, the severe shortage of human resources in Tanzania, currently estimated at 70% [49], will increase and institutional deliveries will be dispersed over a vast number of scantily staffed and poorly equipped peripheral health facilities. Poorer women will pay the toll as they cannot afford to bypass first-line health facilities for delivery [18].

Although the study did not aim to investigate quality of peripheral childbirth services directly, we assessed two aspects of first-line facilities that are essential prerequisites to provide quality of care: availability of skilled staff and case volume. The importance of human resources in the quality of emergency obstetric care and in reducing maternal mortality has been extensively described [50]. Staff shortage and inadequate training have been reported as major barriers to timely and appropriate obstetric care at facility level [51]. Beyond training, caseload is an important factor to maintain skills and to improve outcome quality. In several European countries minimum caseload requirements have been set for surgical procedures to improve

**Table 7. Population coverage by walking distance to health facilities.** Present scenario and projections for reduced number of delivery sites. Network analysis.

| Walking time | Population coverage (%) | | | |
|---|---|---|---|---|
| | *Iringa District* | | *Ludewa District* | |
| | Current delivery sites (N = 71) | Proposed delivery sites (N = 42) | Current delivery sites (N = 55) | Proposed delivery sites (N = 35) |
| ≤ 1 hour | 51.4 | 38.8 | 38.0 | 24.6 |
| ≤ 2 hours | 87.6 | 82.1 | 81.4 | 75.6 |
| > 2 hours | 12.4 | 17.9 | 18.6 | 24.4 |

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patients outcome and there is evidence of association between obstetrical volume and early neonatal mortality [52]. Caseload is particularly relevant to identify BEmOC facilities as a set of signal functions has to be performed at least once every three months [14]. Given the rare onset of obstetrical complications, a large number of deliveries is necessary for each BEmOC facility to perform periodically all signal functions.

Previous studies have addressed the quality gap in first-line health facilities [15, 17,18, 53] and some authors have recommended providing obstetric care only in high-volume settings and not unconditionally at first level [8, 18]. Different solutions have been put forward, such as concentrating deliveries in health centres [19] or offering delivery services at second-line primary health care units [54]. Our data show that locating potential delivery sites with the support of GIS-methods instead of using mere demographic and administrative criteria allows to take into consideration travel time and to ensure physical access. In practice, this could not be implemented exclusively on geographical considerations, but would require discussion with all relevant local stakeholders and involvement of community leaders to avoid decreased utilization of childbirth services.

## Use of network methods in rural areas

Network analysis can provide a reliable picture of women mobility in rural areas. Compared to raster methods where groups of contiguous pixels are considered, network methods can reproduce existing roadmaps and will allow more accurate analysis.

From a methodological point of view our results indicate that network analysis based on real and virtual data allows flexible and accurate simulations in rural contexts and can be adapted to changing scenarios as transport system is developing and travel pattern of pregnant women will change over time.

Findings from network analysis may suggest where to locate resources, such as public transport, ambulances and maternity waiting homes to ensure access to delivery sites for women living beyond two hours [53, 55].

## Strengths and limitations

The main strength of the study is the amount and detail of geographical data collected both in the field and by remote sensing. Furthermore, distance was estimated taking into consideration geographical barriers and was measured as travel time which is more relevant to obstetric services than conventional metric measures. Although straight-line (Euclidean) distance can be reasonably used as a proxy for potential spatial access in flatter areas [56], raster or network methods are more suitable to estimate travel time in mountainous contexts and can supply adequate details for planning at local level.

The lack of official digital topographic maps was a constraint to our study. Road network data were manually updated by digitalizing satellite images from Google Earth™ and Bing but were not always consistent with data provided by local authorities. As routine data are usually less accurate and outdated, we opted for actual data from the field or from satellite images without further opportunity to validate the topographic findings. When updated official digital topographic maps of this area will be available the accuracy of our network method in modelling mobility and travel time will improve.

Another possible limitation might be the arbitrarily chosen 2 hours' walking time cut-off. Although the existing literature does not provide clear standards for maximum acceptable travel time to reach obstetric facilities, a 2 hours' interval is commonly considered sufficient and is in line with available guidelines on childbirth services [21] and previous GIS-based studies [38, 39, 51, 53].

Despite the limited geographical size, the investigated area provides essential information for other rural settings that are planning to increase the health facility numbers with the aim of improving institutional childbirth coverage.

## Conclusions

This study indicates that in a rural high coverage context a 40% reduction of delivery sites will lead to a 7% loss of geographical access. Such careful reduction of delivery sites using GIS modelling methods has the potential to assist decision makers on where to concentrate scarce resources by creating higher volume settings.

Although a small percentage of the population will suffer an increase in distance to health facilities, a policy change in the organization of obstetric services might provide overall improved childbirth care, particularly for the rural poor who preferentially use first-line facilities.

Further research should aim to investigate the effects of the proposed policy adjustment in a limited geographical area. In particular, the effect of fewer strengthened delivery sites on maternal and newborn mortality should be assessed, and whether the loss of proximity affects institutional delivery coverage.

## Supporting Information

**S1 Dataset. Ludewa District health facilities dataset.** Staffing level and number of deliveries. 2012. Ludewa District, Tanzania.
(XLS)

**S2 Dataset. Iringa District health facilities dataset.** Staffing level and number of deliveries. 2012. Iringa District, Tanzania.
(XLS)

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## Author Contributions

Conceived and designed the experiments: PF MS CB PLF. Performed the experiments: PF MS CB PLF RMS HMM GA. Analyzed the data: PF MS CB PLF. Contributed reagents/materials/analysis tools: PF MS CB PLF. Wrote the paper: PF MS CB PLF RMS HMM GA GP.

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MISCELLANEOUS

# Effect of a Neonatal Resuscitation Course on Healthcare Providers' Performances Assessed by Video Recording in a Low-Resource Setting

In Mozambique neonatal mortality is 34 neonatal deaths per 1,000 live births, accounting for approximately 35% of under-5 deaths. Around 25% of these neonatal deaths is linked to delivery-related events, in particular breathing problems. Indeed, the intervention of health care personnel is required when newborns are unable to breathe spontaneously, but in lower-income countries health workers are often unprepared to handle such emergencies.

This highlights the importance of training health care professionals in the area of emergency neonatal care.

Carried out in 2014 in the central hospital in Beira, Mozambique, this study assessed the work of the health care staff in charge of the delivery room (16 midwives) prior to and after having undergone a day of training on neonatal resuscitation.

The assessment was undertaken using a new methodology meant specifically for settings in lower-income areas: a webcam was placed in the delivery room to record the activities of the hospital's sixteen midwives for the duration of the study as they handled 100 newborns – 50 before undergoing training and 50 afterwards.

Although they failed to fully meet the recommended standards both in terms of actions taken and their timing, after undergoing the day-long training course the midwives improved their resuscitation performances at every level. They achieved a score of 44% for the initial steps (correct positioning of the infant's head, preparation of materials, and so forth), in comparison with the 33% score achieved prior to the course; moreover, they also improved their performance in terms of the use and positioning of oxygen masks (from 20% to 40%) and cardiothoracic resuscitation (from 0% to 20%).

PLOS ONE

RESEARCH ARTICLE

# Effect of a Neonatal Resuscitation Course on Healthcare Providers' Performances Assessed by Video Recording in a Low-Resource Setting

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## Abstract

### Background

We assessed the effect of an adapted neonatal resuscitation program (NRP) course on healthcare providers' performances in a low-resource setting through the use of video recording.

### Methods

A video recorder, mounted to the radiant warmers in the delivery rooms at Beira Central Hospital, Mozambique, was used to record all resuscitations. One-hundred resuscitations (50 before and 50 after participation in an adapted NRP course) were collected and assessed based on a previously published score.

### Results

All 100 neonates received initial steps; from these, 77 and 32 needed bag-mask ventilation (BMV) and chest compressions (CC), respectively. There was a significant improvement in resuscitation scores in all levels of resuscitation from before to after the course: for "initial steps", the score increased from 33% (IQR 28–39) to 44% (IQR 39–56), $p<0.0001$; for BMV, from 20% (20–40) to 40% (40–60), $p = 0.001$; and for CC, from 0% (0–10) to 20% (0–50), $p = 0.01$. Times of resuscitative interventions after the course were improved in comparison to those obtained before the course, but remained non-compliant with the recommended algorithm.

### Conclusions

Although resuscitations remained below the recommended standards in terms of quality and time of execution, clinical practice of healthcare providers improved after participation

in an adapted NRP course. Video recording was well-accepted by the staff, useful for objective assessment of performance during resuscitation, and can be used as an educational tool in a low-resource setting.

## Introduction

Each year about 6.6 million children worldwide under the age of 5 die and of these 44% are newborns. According to the World Health Organization, about a quarter of these newborns die in the first 24 hours. To these, we must add the 3 million stillbirths recorded annually [1–3].

In 2012, the neonatal mortality rate in Mozambique was estimated at 34/1000 live births. The rate of stillbirth was 28/1000 total births. Neonatal deaths constituted 35% of an estimated 85000 deaths under five years of age [4].

Intrapartum-related events, previously called "birth asphyxia", account for a quarter of neonatal deaths [5]. Initiation of breathing is critical in the physiologic transition from intrauterine to extrauterine life. Approximately 85% of babies born at term will initiate spontaneous respirations within 10 to 30 seconds of birth, an additional 10% will respond during drying and stimulation, approximately 3% will initiate respirations after positive-pressure ventilation (PPV), 2% will be intubated to support respiratory function, and 0.1% will require chest compressions (CC) and/or epinephrine to achieve this transition [6].

Therefore, training programs on neonatal resuscitation for all health workers involved in the management of the newborn at birth are a critical priority to improve neonatal survival [7–11]. Previous studies aimed at assessing the effect of such training programs showed an improvement in the knowledge and skills of the healthcare providers and their degree of comfort in the execution of interventions in high as well as low-resource settings. [12,13]. This improvement, however, did not always translate into a sustainable and long-term improvement in clinical practice in the delivery room [13–15]. This problem could be due to several factors such as poor quality of clinical practices, lack of leadership and supervision, limited availability of supplies and equipment, and low involvement of health workers in organizational and training programs.

Other studies showed that implementing educational programs on neonatal resuscitation in low-resource settings resulted in a reduction of the rate of stillbirths without substantial reductions in the neonatal mortality rate [16]. Therefore, there is a need to confirm that the knowledge and skills taught are consistently and reliably applied during actual clinical practice.

Recently, video recording has been used as a means of evaluating neonatal resuscitation performance of health caregivers in high-resource settings [17–19]. These studies documented a significant number of deviations from the guidelines [18,19]. To date, there have been no reports on the use of videotaping as a means of assessing the quality of neonatal resuscitations in low-resource countries. This study was the first to objectively examine the effect of resuscitation training on provider practices in a true clinical low-resource setting. Our aim was to use video recording to compare the performances of health providers in a low-resource setting before and after participation in an adapted neonatal resuscitation program (NRP) course.

## Methods

### Setting

This prospective observational study was conducted at Beira Central Hospital, in the province of Sofala, Mozambique where about 4500 deliveries occur every year. Beira Central Hospital is

the referral hospital for a geographical area that covers about 7 million people. This center was selected for the study because it is a level III hospital with large referral services for maternal and neonatal care [4]. The study protocol was approved by the National Committee of Bioethics (Ref. 315/CNBS/13; November, 1, 2013) and by the Minister of Health of the Republic of Mozambique (Ref. 08/GMS/002/2014; January, 7, 2014). Parental consent to record neonatal delivery room management and to use the data was obtained before delivery. Written informed consent was given by parents or caregivers for clinical records to be used in this study. All information, including informed consent and all the material used in the study was written in Portuguese in a clearly understandable form.

## Patients

All neonates who needed resuscitation of any form at birth were included in the study. We defined resuscitation as any intervention by healthcare providers: initial steps in order to initiate spontaneous breathing, bag mask ventilation, and/or chest compressions. Lack of parental consent was the only exclusion criterion.

## Study design

All 16 midwives responsible for immediate postnatal management of the newborns at Beira Hospital participated in the study. Participation was mandatory. The study had 3 phases: a) baseline period (data on 50 resuscitations were collected by video recording); b) intervention period (all birth attendants attended a one-day, adapted Neonatal Resuscitation Program (NRP) course); and c) post-intervention period (data on a further 50 resuscitations were collected). The algorithm of 2010 American Heart Association Guidelines was used for the course [7,10]. The NRP algorithm suggests to start PPV at 30 seconds after birth; in case of heart rate less than 60 beats/min despite 30 seconds of effective PPV, CC have to be administered for about 60 seconds; if, despite CC and effective PPV the heart rate remains less than 60 beats/min, medication administration is recommended [7,10].

The adapted NRP course was held in Portuguese by two neonatologists certified as NRP instructors. The training drew heavily on the NRP training in form [20], but was significantly adapted to the Mozambican setting where resources are limited. These adaptions to the NRP training program have not been previously validated or studied. The course teaches an A (Airway), B (Breathing) and C (Circulation) approach to resuscitation laying down a clear step-by-step strategy for the first minutes of resuscitation at birth. We did not include intubation and drug administration because they were not feasible in this setting. The course was comprised of focused lectures aimed at understanding the approach to resuscitation, skill stations and practical scenario sessions using neonatal manikins (Neonatal Resuscitation Baby, Laerdal, Stavanger, Norway) to develop skills in airway opening, bag-mask ventilation (BMV) and CC.

At Beira Central Hospital, neonatal resuscitation is performed routinely on overhead radiant warmers in the delivery room or in the obstetric operating room. Midwives are responsible for immediate postnatal care of all neonates, including resuscitation. The available equipment consists of gloves, clean towels, wall suction device, suction catheters, bulb suction, a self-inflating bag in combination with two face masks (size 0 and 1) and an oxygen source. Neonatal resuscitation is based on the NRP algorithm with the exclusion of intubation and medication administration [7,20].

## Video recording

Interventions were recorded using a webcam for video monitoring (ENXDVR-4C, Encore Electronics. www.encore-usa.com), consisting of 1 fixed camera installed above the radiant

warmers both in the delivery room and in the operating room. The cameras provided a 24 hour video recording without audio. The image was zoomed to show only the newborn and the hands of the resuscitation team. Parents, obstetric procedures and faces of the caregivers were not visible [17]. The video camera displayed a continuous time readout at the bottom of the recorded image allowing timing of performed procedures to the nearest second. All videos were stored on a hard disk and sent to the coordinator center (University of Padua). In order to protect the identities of the subjects and the data, all data about resuscitation date and location were removed, and shipment was insured. A skilled neonatologist–aware of the adapted NRP course but blinded to the pre/post-intervention—evaluated and scored each resuscitation according to a previous study [19]. Evaluation of intubation and medications was not included in the score since these steps are not performed in low-resource settings. The modified scoring system is shown in S1 Table.

A composite score was devised to assign a numerical score for each resuscitation. Two points were awarded for every correct decision and every properly performed procedure. One point was awarded if the intervention was delayed or the technique for a given procedure was inadequate. No points were awarded for indicated procedures that were omitted or for performed procedures that were not indicated. The sum of the awarded points was divided by the total possible points for that level of resuscitation (initial steps, BMV and CC) to obtain a percentage score. The "start time" and "stop time" of each procedure was recorded; the "duration of each procedure" could then be calculated from those times.

Maternal and neonatal data were also recorded in a data collection sheet.

### Statistics

Since there were no prior studies of video recording in evaluating neonatal resuscitation performance and in teaching activity in low-resource settings, the sample size was arbitrarily estimated at 50 resuscitations before the course and 50 after the course. Data were expressed as number and percentage or as median and interquartile range (IQR). Categorical data were compared using the Fisher test, whereas continuous data were compared using the Mann-Whitney test. A p-value of less than 0.05 was considered statistically significant. Statistical analysis was performed using R 2.12 software (R Foundation for Statistical Computing, Vienna, Austria).

## Results

### Adapted NRP course

The adapted NRP course was held on January 31, 2014. The median age of the participants was 30 years (IQR 28–36); they had a median of 7 years (4–10) of experience in the delivery room and they had already participated in 2 adapted NRP courses (IRQ 1–2) in the past.

### Patients

During the baseline period (from Jan 11 to Jan 31, 2014), 50 out of 302 (16.5%) neonates were resuscitated; during the post-intervention period (from Feb 2 to March 6, 2014), resuscitation manoeuvres were performed on 50 out of 466 (10.7%) neonates. Maternal and neonatal characteristics of the 2 groups are reported in Table 1.

All 100 neonates received the initial steps of resuscitation; of them, 77 and 32 needed BMV and CC, respectively.

**Table 1. Maternal and neonatal characteristics.**

| | Before training | After training | p-value |
|---|---|---|---|
| Number of resuscitations | 50 | 50 | - |
| **Maternal data** | | | |
| Age, years * | 23 (19–29) | 23 (19–28) | 0,57 |
| Antenatal visits * | 4 (3–6) | 4 (3–6) | 0,93 |
| Previous pregnancies * | 3 (1–4) | 2 (1–3) | 0,53 |
| First pregnancy | 17 (34) | 21 (42) | 0,54 |
| HIV infection | 10 (20) | 12 (24) | 0,81 |
| Mode of delivery | | | 0,42 |
| *cesarean section* | 23 (46) | 28 (56) | |
| *vaginal delivery* | 27 (54) | 22 (44) | |
| Amniotic fluid: | | | 0,27 |
| *clear* | 39 (78) | 33 (66) | |
| *meconium stained* | 11 (22) | 17 (34) | |
| Complications | 32 (64) | 36 (72) | 0,52 |
| *Placental abruption* | 0 | 4 | |
| *eclampsia/preeclampsia* | 12 | 16 | |
| *dystocia* | 6 | 10 | |
| *uterine rupture* | 2 | 0 | |
| *other* | 8 | 0 | |
| **Neonatal data** | | | |
| Gender male:female | 32:18 | 35:15 | 0,67 |
| Birth weight, g * | 2800 (2200–3000) | 2950 (2500–3300) | 0,07 |
| Gestational age, weeks * | 38 (35–40) | 38 (37–40) | 0,33 |
| Apgar score at 1' * | 5 (1–7) | 4 (3–6) | 0,49 |
| Apgar score at 5' * | 6 (2–8) | 6 (4–7) | 0,73 |
| Deaths, n | 13 (26) | 14 (28) | 0,99 |

Data are expressed as n (%) or * median (IQR).

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## Primary outcome

Fig 1 shows the percentage scores obtained before and after the course in the three levels of resuscitation.

Within the "Initial steps", a statistically significant improvement was noted for "preparation of material" ($p = 0.05$), "positioning of the head" ($p = 0.01$), "drying" "$p = 0.001$), and "stimulation" ($p = 0.01$). (Fig 2) BMV improved in the items "starting ventilation with room air" ($p = 0.0003$) and "correct positioning of the face mask" ($p<0.0001$). (Fig 3) All the items included in CC intervention improved with the exception of the frequency of heart rate assessment, which decreased after the course. (Fig 4)

## Timing of interventions

With the exception of "tactile stimulation", the median start times of all interventions began sooner after the adapted NRP course in comparison to those performed during the baseline period.

The start time and the duration of each intervention did not adhere to times recommended by the NRP algorithm both before and after the course. (Table 2, Fig 5)

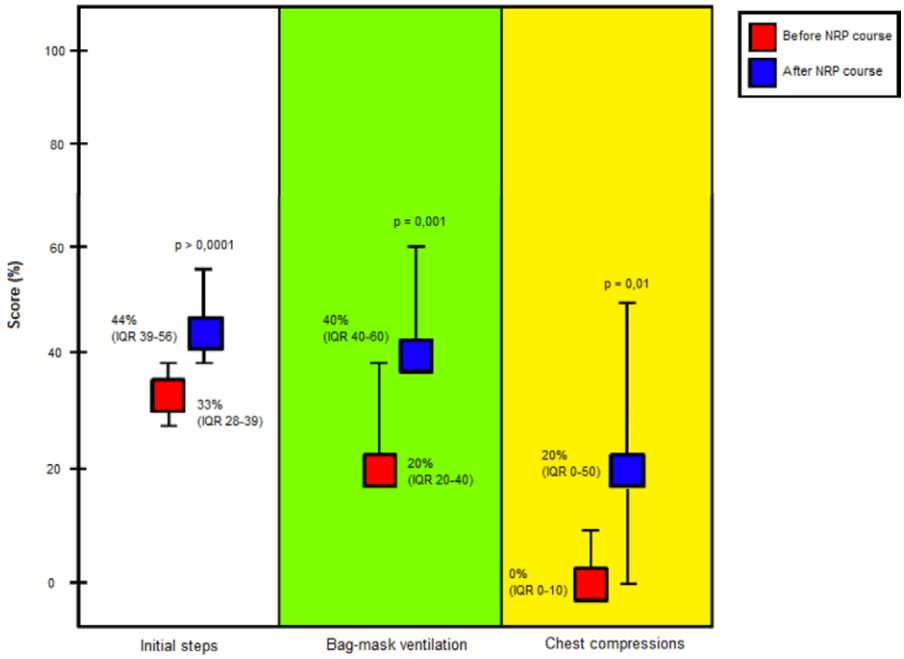


**Fig 1. Total scores before and after the course in the three levels (initial steps, BMV and CC) of resuscitation.** Data are expressed as median (interquartile range).

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## Discussion

In this study, video recording was used to assess the performance of healthcare providers before and after participation in an adapted NRP course in a low-resource setting. Our results show that although resuscitations remained below the recommended standards in terms of quality and time of execution, clinical performance of healthcare providers improved after participation in an adapted NRP course. In addition, our study provides further information on the utility of video recording for human performance assessment, as instituted in a simplified fashion in a low-resource setting.

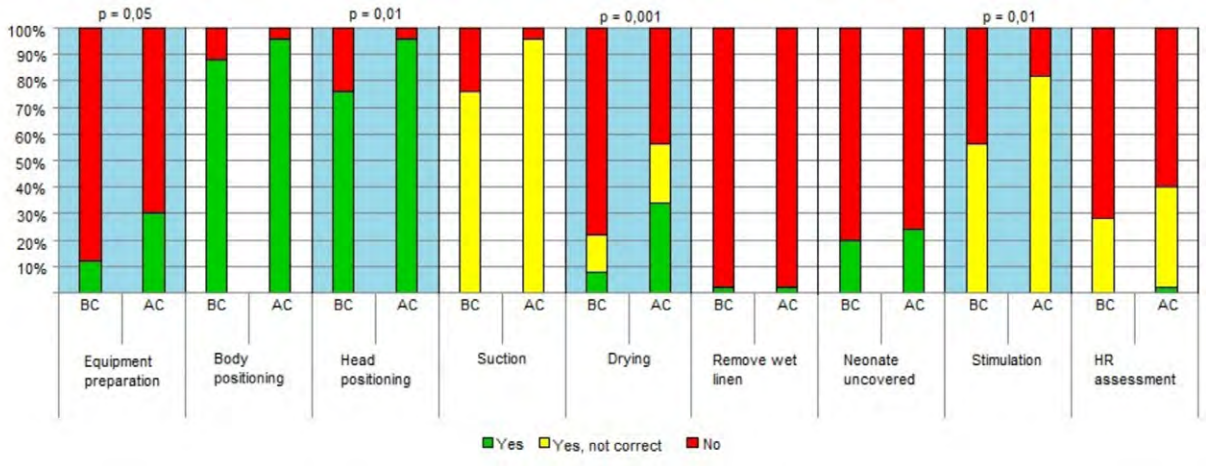


**Fig 2. Detailed scores before and after the course in initial steps.** (see S1 Dataset). Legend: AC, after the course; BF-before the course; HR- heart rate.

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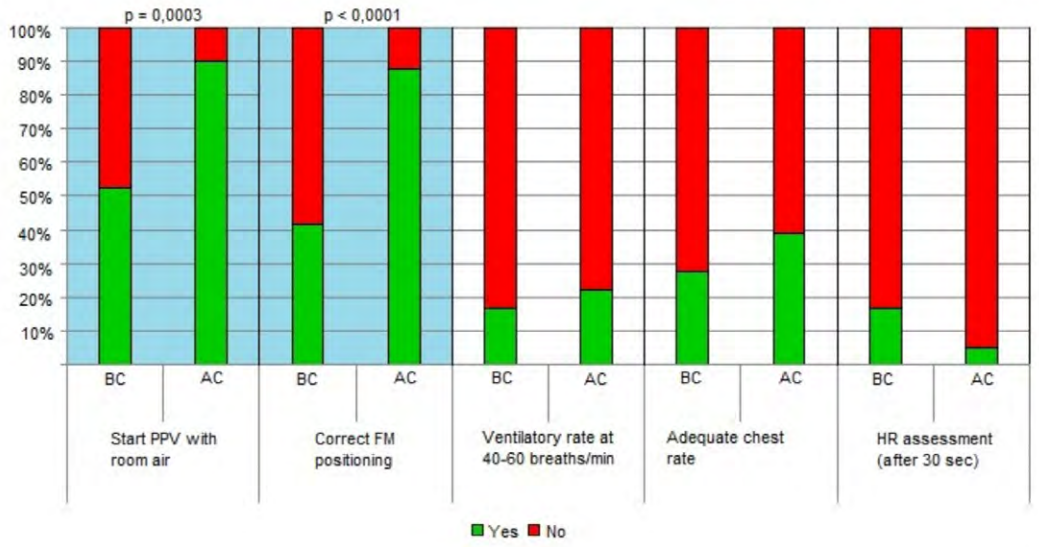


**Fig 3. Detailed scores before and after the course in BMV.** (see S1 Dataset). Legend: AC, after the course; BF-before the course; FM-face mask; HR-heart rate; PPV- positive pressure ventilation.

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One-fourth of neonatal deaths each year are attributed are attributed to intrapartum-related events, previously called "birth asphyxia"; of these, nearly all (99%) occur in low and middle income countries. Among the survivors of intrapartum-related events, one million may develop cerebral palsy, learning difficulties, or other forms of disability each year [1–3]. A recent observational study conducted in a Tanzanian rural hospital indicates that asphyxia accounts for a much higher percentage of neonatal deaths in the first week of life (61%) [21], suggesting the urgent need for training programs on neonatal resuscitation for all healthcare workers involved in the management of newborns at birth. Whereas studies on the effects of life support training for any age group of patients have been conducted, their focus is mostly

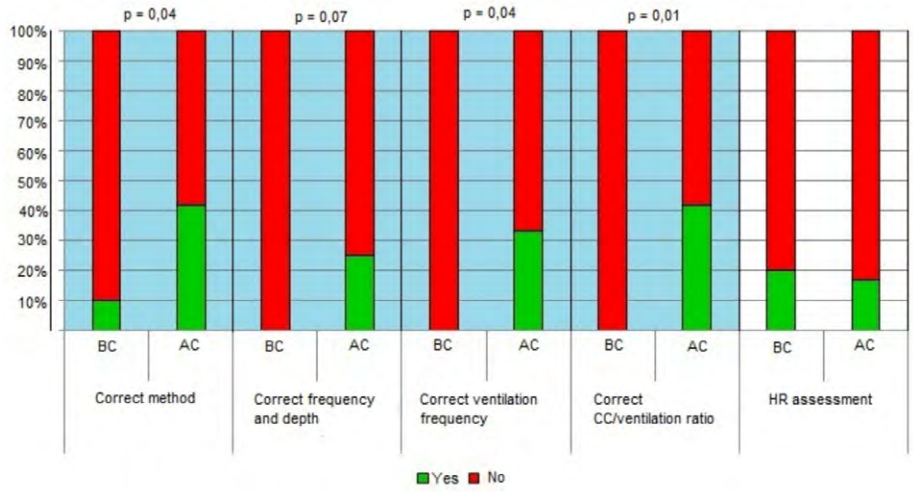


**Fig 4. Detailed scores before and after the course in CC.** (see S1 Dataset). Legend: AC, after the course; BF-before the course; CC- chest compressions; HR- heart rate.

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**Table 2. Time of initiation and duration of procedures.**

| | Before training | After training | p-value |
|---|---|---|---|
| Total time of procedure | 391 (288–680) | 366 (263–606) | 0,75 |
| Time elapsed from birth to starting resuscitation | 21 (0–72) | 10 (0–29) | **0,008** |
| **Suction** | | | |
| *Number of interventions* | 48 | 45 | - |
| *Start time of first suction* | 94 (64–144) | 73 (40–119) | 0,07 |
| *Duration of first intervention* | 99 (50–158) | 76 (46–127) | 0,25 |
| *Number of interventions* | 1 (1–2) | 1 (1–2) | 0,16 |
| *Total duration* | 125 (60–177) | 117 (66–160) | 0,53 |
| **Stimulation** | | | |
| *Number of interventions* | 28 | 41 | - |
| *Start time of first stimulation* | 146 (36–252) | 178 (98–239) | 0,55 |
| *Duration of first intervention* | 4 (3–9) | 12 (5–20) | **0,0003** |
| *Number of interventions* | 1 (1–1) | 1 (1–2) | 0,2 |
| *Total duration* | 5 (3–10) | 14 (6–28) | **0,0005** |
| **Heart rate evaluation** | | | |
| *Number of interventions* | 14 | 20 | - |
| *Start time of first heart rate evaluation* | 116 (30–233) | 110 (22–177) | 0,86 |
| *Number of interventions* | 2 (1–4) | 1 (1–3) | 0,59 |
| **Bag-mask ventilation** | | | |
| *Number of interventions* | 36 | 41 | - |
| *Start time of first bag-mask ventilation* | 220 (135–300) | 138 (110–226) | **0,03** |
| *Duration of first intervention* | 40 (16–82) | 67 (30–134) | 0,06 |
| *Number of interventions* | 2 81–3) | 2 (1–3) | 0,64 |
| *Total duration* | 83 (32–234) | 157 (70–263) | 0,24 |
| **Chest compressions** | | | |
| *Number of interventions* | 20 | 12 | - |
| *Start time of first chest compressions* | 315 (187–466) | 241 (137–513) | 0,74 |
| *Duration of first intervention* | 59 (22–108) | 47 (44–97) | 0,82 |
| *Number of interventions* | 1 (1–2) | 2 (1–2) | 0,24 |
| *Total duration* | 73 (33–121) | 105 (52–182) | 0,15 |

Data (seconds) are expressed as median (IQR). *"Number of interventions"* means number of (separate) episodes of that intervention.

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on knowledge and skill retention observed in simulated practice following course participation. Few studies have examined outcomes considered more meaningful such as morbidity, mortality or work-place provider practices [9–11,14,15,22].

Previously, video recording was used as a means of evaluating neonatal resuscitation performance of healthcare providers [18,19]. In particular, this approach allowed researchers to: 1) determine the actual conduct of neonatal resuscitation in a specific institution; 2) compare that resuscitation against the standards set forth by the American Heart Association guidelines for neonatal resuscitation (i.e. NRP program) [7]; and 3) re-educate and improve performance [18,19].

This study represents the first prospective analysis of neonatal resuscitation in a low-resource clinical setting. We objectively assessed the performances of midwives involved in neonatal resuscitation before and after participation in an adapted NRP training program. Similar to previous studies conducted in high-resource countries [18,19,23], we found several deviations from NRP guidelines.

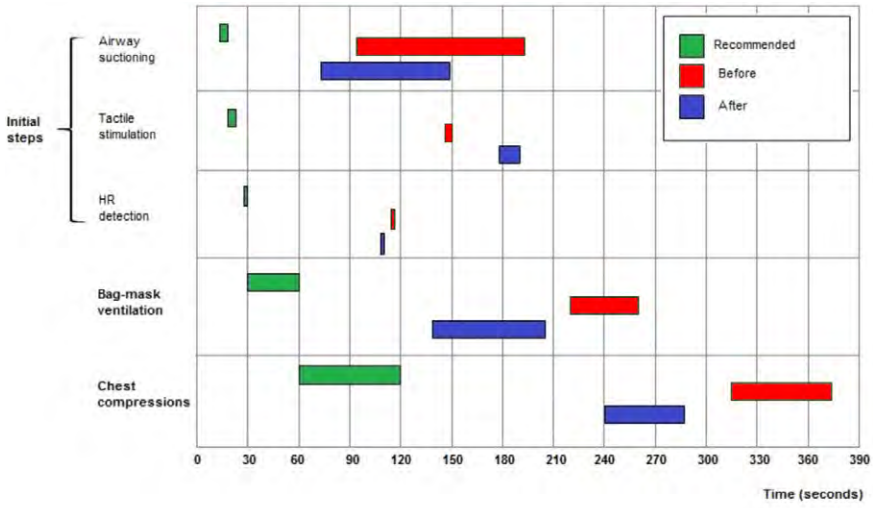


**Fig 5. Initiation times and duration of procedures.** Data are expressed as medians.

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Although midwives had a long experience (average 7 years) in the delivery room and had previously participated in a median of 2 adapted NRP courses, the percentage of correct procedures before the course was very low for all resuscitation interventions (initial steps, BMV and CC). After the course, we noted an overall improvement, with the most significant improvements noted for positioning of the head, drying, stimulation, starting ventilation with room air, and correct positioning of the face mask.

The opportunity to analyze the videos allowed us to assess in depth the three levels of resuscitation (initial steps, BMV and CC) and showed that the application of knowledge and skill retention in clinical practice depends on the specific intervention. For example, initiation of BMV with room air instead of 100% oxygen or the correct positioning of the face mask were easier to teach (and learn) than the correct ventilatory rate, effective chest movements and detection of the heart rate. On the contrary, the frequent and aggressive use of deep suctioning was clearly documented, with the course having no impact in changing this practice. These findings are difficult to interpret and need to be discussed in depth with participants to understand the reasons of "failure" and "success" of the course on clinical practice. Based on the results of the present study, we have planned a further educational intervention consisting in two phases: a) a local instructor holds weekly sessions on a manikin for delivery room healthcare providers; b) during the last week of the month, video cameras are switched on to collect data on resuscitation practices with the purpose of documenting the improvements and eventually provide a personalized learning curve. In this context, the information obtained through the use of video recordings can provide useful and objective feedback to both the teaching staff as well as the participants of the NRP course. This feedback helps in identifying the strengths and weaknesses of the educational intervention.

A further important finding of the present study concerns the times of resuscitation interventions. We found that the times of initiation and duration of all procedures were inconsistent with the times recommended by NRP algorithm [7]. Median times from birth to initiation of suction, heart rate detection, BMV and CC decreased in the period after the course, but remained longer than those recommended. This information should be discussed with the resuscitation team to understand the reasons for this delay. However, it must be noted that the poor performance of health care providers has multiple determinants [24].

In line with previous studies conducted in high-resource settings, it was found that the staff adapted very quickly to the presence of the recorder [19]. The system was very simple to use, unobtrusive and did not interfere with staff activity.

The strength of the present study is the objective assessment of healthcare worker performance in a low-resource delivery room through the use of video recording. Nevertheless, it has some limitations that should be considered when interpreting the results. A small number of participants were involved in the study, although they represented the entire staff involved in the care of the 4500 newborns born at Beira Central Hospital. Although this situation reflects a typical organizational and cultural environment of a referral African delivery setting, our results could be different in other contexts. The training was based on the NRP course significantly adapted to a low-resource setting; other educational initiatives such as "Helping Babies Breathe" program could have a different impact [25]. We chose to implement a modified NRP training program in this low-resource setting, rather than the Helping Babies Breathe curriculum because previous NRP courses were held in this hospital and because the trainers were certified as NRP instructors. However, with the exception of small differences such as the time of heart rate assessment, the algorithms are very similar between the two programs.

Previous studies have raised some concerns on the validity of video monitoring [26], however we believe that the limitations of this system (ie, single view of patient or inability to capture all resuscitations in all delivery rooms) are minor relative to the strengths of the system.

While there is increasing pressure to implement training programs on neonatal resuscitation in developing countries, it is important that their true effects on actual healthcare provider performance and neonatal morbidity and mortality are established. Such studies need to be based in typical, low income settings where supervision and opportunities for continuous learning or ongoing mentorship and resources for post-resuscitation care may be limited.

## Conclusions

The primary purpose of this study was to use video recording to evaluate the effect on healthcare provider performance of an adapted NRP course in a low-resource setting. Our results show that although resuscitations remained below the recommended standards in terms of quality and time of execution, clinical performance did show some improvement after the course. In addition, staff adapted very quickly to the presence of the recorder. Video recording is useful for objective assessment of staff performance during resuscitation and can be used as an educational tool. However, it remains to be established if it could be helpful to improve resuscitation practices in a low-resource delivery room. Our study highlights that the current practice may be insufficient to improve outcomes in this highly important clinical setting, and evaluation of further methods to improve this area of practice is warranted.

## Supporting Information

**S1 Dataset. Dataset.**
(PDF)

**S1 Table. Modified scoring system.**
(PDF)

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## Author Contributions

Conceived and designed the experiments: DT FB PL FC GP. Performed the experiments: FB EM OWM EG. Analyzed the data: DT FC LDD. Wrote the paper: DT FC GP. Read and approved the final report: DT FB PL FC EM OWM EG LDD GP.

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# MATERNAL AND CHILD HEALTH

## ORAL PRESENTATIONS

# Changes in Utilization of Delivery Services in Karamoja and Associated Trends in Institutional Maternal Mortality


## Author

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## Background

Access to and utilization of quality maternal services are crucial to reducing maternal mortality. We explore the effects of multiple interventions on facility deliveries at different levels of the health system in Karamoja and demonstrate the associated reduction in health unit maternal deaths.

## Methods

This retrospective study reviewed health records with emphasis on institutional deliveries and maternal deaths at health facilities in Karamoja for 27 months (Jan 2013- Mar 2015). Doctors with Africa CUAMM and UNICEF Uganda implemented multiple interventions in Karamoja to accelerate access to and utilization of quality maternal and neonatal services in the region. These included, transport voucher scheme, staff training and continuous mentoring, equipment, solar lighting and cultural adaptation of health unit delivery including birth cushions. Routine data from all 115 health units that conducted deliveries from 2012 (baseline) to March 2015 were collected. We used a before and after analysis to evaluate the effects of the interventions. The key outcomes were facility deliveries and maternal death in health units.

## Results

Overall, total deliveries increased by 95%, from 11,425 in 2012 to 22,271 in 2014; 80% of the additional deliveries were in health centre (HC) 2s and 3s. HC2s alone contributed 32.3% (3,505/10,846) of additional deliveries and 21% of total deliveries compared to 9% in 2012. These increased deliveries were associated with declining reported institutional maternal deaths from 291/100,000 deliveries at the peak to 31 in quarter1 2015. Figure 1 below, shows the trends in institutional deliveries and maternal deaths.

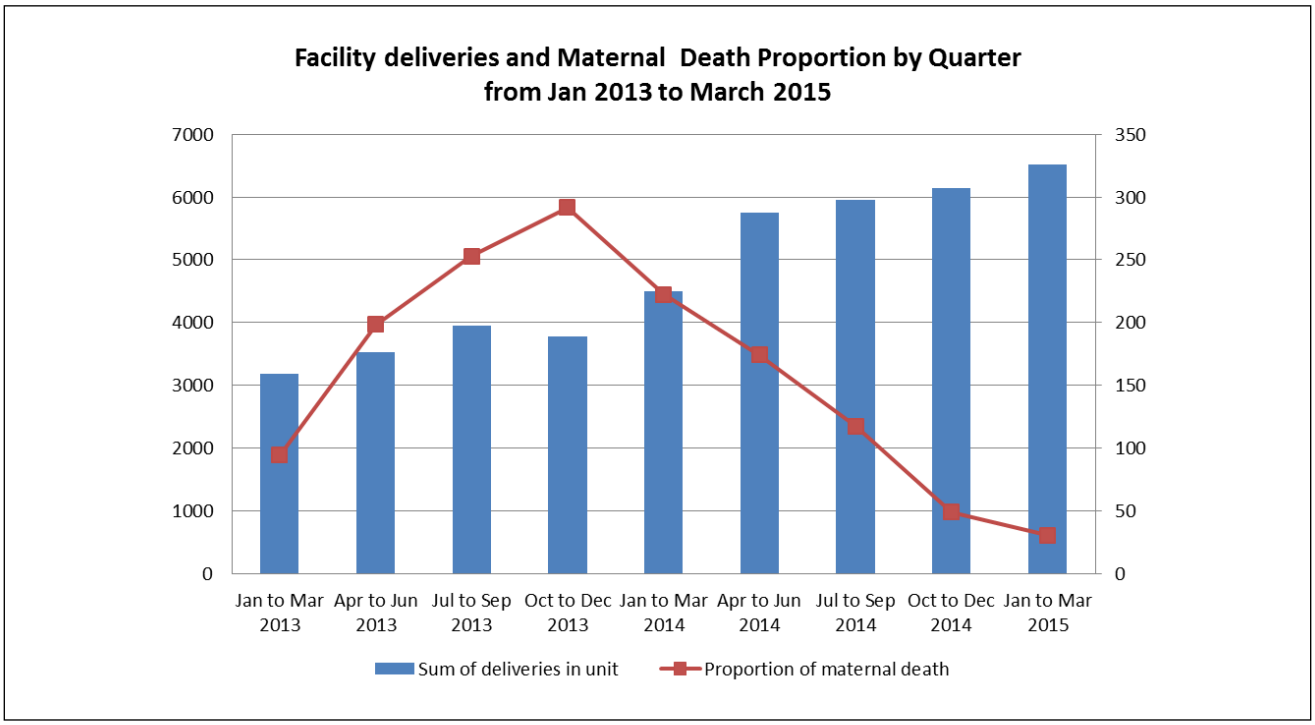


Fig 1: Trends in institutional deliveries and maternal deaths, Karamoja

## Conclusion

The Combined interventions clearly increased health facility deliveries. Preference for near facilities especially HC 2s for delivery services stands out strongly. There is urgent need to strengthen HC 2s to provide delivery services to achieve universal coverage of institutional deliveries, contrary to current policy.

**Key words: Deliveries, Health units, Interventions, Karamoja, Maternal deaths**.




# Changing Roles of Traditional Birth Attendants and their Effects on Institutional Deliveries in Karamoja, Northern Uganda


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## Objective

We examine the changing roles of traditional birth attendants (TBAs) and their contributions to institutional deliveries in Karamoja, northern Uganda.

## Methods

We conducted retrospective chart reviews focusing on deliveries by TBAs and health facilities in Karamoja for 2 years (2012-2014). Over the study period, several interventions were implemented related to maternal and child health. They included improvement of the quality of services, and training of TBAs and other family birth attendants as peer mothers to refer and accompany pregnant women to deliver at health facilities. TBAs also had a new role as "transporters" and received incentives for their contributions. Data on institutional and TBA deliveries were collected and analysed using SPSS 16 and Microsoft Excel Programme version 2013. Study outcomes were changes in deliveries by institutions and TBAs.

## Results

Overall, institutional deliveries increased by 26.3 % and 54.7%, from 2012 to 2013 and 2013 to 2014 respectively. Reported TBA deliveries from the communities contributed 41.5% in 2012, 31.0% in 2013 and 14.4% in 2014 to the total reported deliveries. The increase in total reported deliveries was associated with improved institutional deliveries, but decreasing reported TBA deliveries by 10.5% in 2013 and 27.1% in 2014.

## Conclusion

Training TBAs and family members with similar roles to refer, accompany and or transport pregnant women to deliver at health facilities has greatly improved institutional deliveries in Karamoja. The changing roles of TBAs could indirectly reduce maternal deaths in the region.



**Key words: Institutional deliveries; Interventions; Karamoja; Peer mothers; TBA; Transporters**.

*Operationalizing maternal and newborn health for sustainable development goals in Uganda*

# Complications in Pregnancy, Delivery and Post-delivery and their Trends in the Karamoja Region, Uganda


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## Background

Complications in pregnancy, delivery and post-delivery contribute significantly to maternal mortality in Uganda. We examined complications related to pregnancy, delivery and post-delivery and their trends, and explored the effects of several interventions on these outcomes.

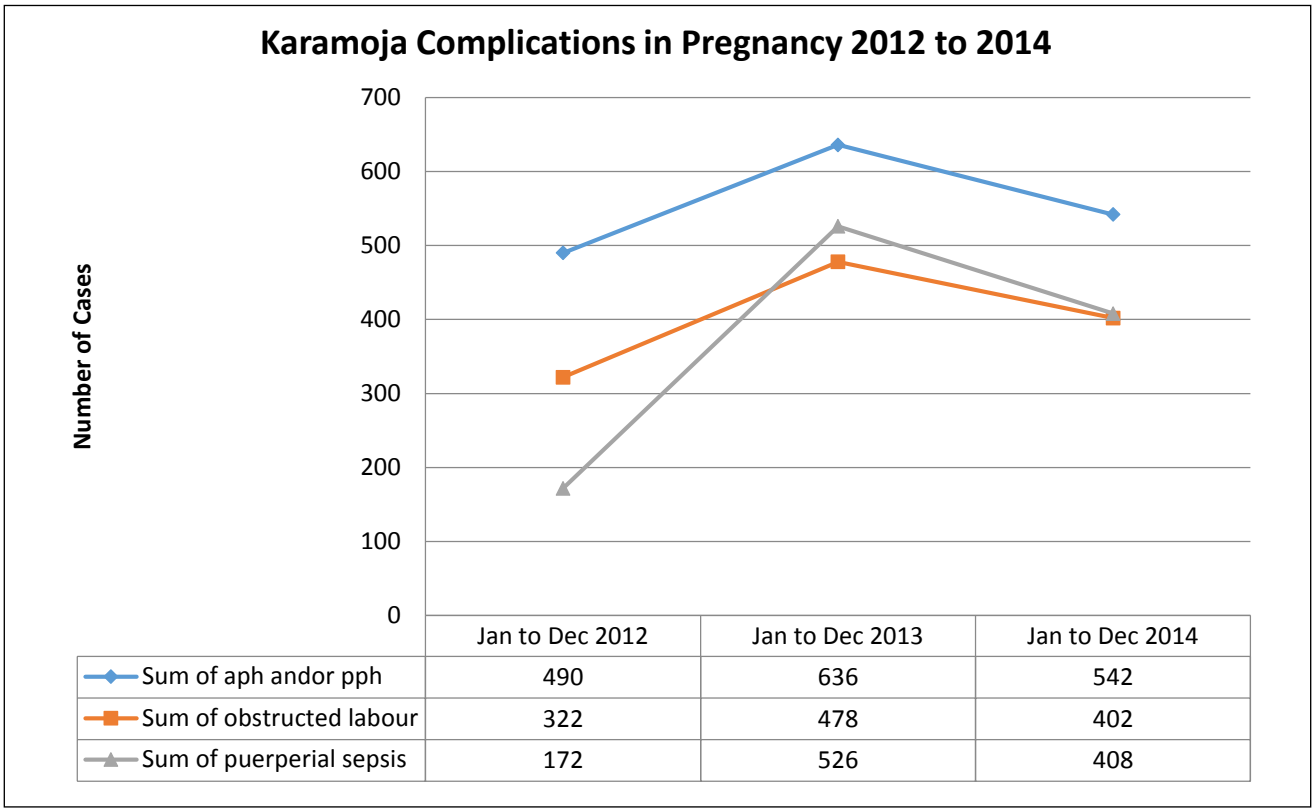
## Methods

We conducted retrospective chart reviews looking at complications related to pregnancy, delivery and after delivery at health facilities offering basic and comprehensive maternal health care in the seven districts of the Karamoja region for 2 years (2012-2014). During that period, UNICEF and Doctors with Africa CUAMM implemented four interventions to improve maternal health care. They included transport voucher scheme, birth cushions, solar suitcase for lighting and senior midwife supervisors to train and mentor junior midwives in health units. We collected maternal health data using the routine health management information system tools. Deliveries, obstructed labour, puerperal sepsis, ante partum (APH) and post-partum hemorrhage (PPH) were outcomes of interest, and these were analyzed using Microsoft Excel Programme version 2013.

## Results

Generally, deliveries increased by 26% and 95% in 2013 and 2014 respectively, compared to 2012 (baseline). Complications increased in the first year but started decreasing by the second. APH and PPH increased by 30%, puerperal sepsis by 205% and obstructed labour by 48%. In the second year (2014), APH and PPH decreased by 15%, puerperal sepsis by 22% and obstructed labour by 16% compared to 2013. The complications and their trends are illustrated in figure 1 below.

Fig 1: Pregnancy and labour related complications and trends in Karamoja




## Conclusion

The multiple interventions increased facility deliveries and appeared to be associated with increased complications in the first year. However, the decreasing trends in complications in the second year despite increasing deliveries seem to suggest improved quality of care, particularly, detection and preventive management of 'potential complication cases'.

**Key words: Maternal health; pregnancy; delivery; post-delivery; complications; interventions**

# Effectiveness of Demand-side Incentives on Utilisation of Delivery Services in Oyam District, Uganda: A Quasi-Experimental Study


## Author

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## Background and Objective

Skilled attendance at birth is indispensable in preventing maternal deaths, yet many pregnant women deliver at home in Uganda due to various barriers in accessing health care. We aimed to evaluate the effects of transport vouchers and baby kits on institutional delivery and other maternal health services in Oyam district, Uganda.

## Methods and materials

A quasi-experimental study involving purposively selected intervention and comparable control sub-counties was conducted in the Oyam District, over 12 months (2013- 2014). Two interventions were evaluated: transport vouchers and baby kits. Transport vouchers were given to pregnant women attending ANC and or delivering in Acaba sub-county, which has two health centre (HC) IIs, whilst baby kits were given to pregnant women who delivered at Ngai HC III, the only HC in Ngai sub-county. Baseline and end line data were collected in 2013 and 2014 respectively. Study outcomes included coverages of institutional delivery, ANC visit4 and PNC. The effect of each intervention on study outcomes was calculated using difference in differences (DID) analysis. A falsification exercise was performed based on outpatient services utilisation.

## Results

Institutional delivery coverage increased from 25% (407/1629) to 45% (734/1629) for baby kits, and from 13% (224/1689) to 48% (811/1689) for transport vouchers. Generally, transport vouchers had a greater impact on ANC 4 and PNC, whilst baby kits had a greater influence on institutional delivery. The absolute increase in institutional delivery coverage attributable to the baby kits was 22.1%. Similarly, transport vouchers increased ANC 4 and PNC coverages by 24.2% and 28.6% respectively. None of the interventions affected outpatient services utilisation.

## Conclusion

Clearly, the demand side incentives were effective in increasing utilisation of delivery, ANC and PNC services and thus have the potential to improve maternal and neonatal health in this setting.



**Key words: Demand-side incentives, maternal health, Uganda**

# Accelerating Access and Utilization of Maternal and Neonatal Services in an Extremely Poor and Remote Region of Uganda


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## Objective

In Uganda, Karamoja region with 1.02 million inhabitants poses major development challenges, 75.8% of people live below the poverty line, infant mortality is 87, Under-5 mortality is 153 and MMR is estimated at 750/100,000. Access to and utilisation of maternal, neonatal and child services is poor due to health system, geographical and socio-cultural challenges. The districts in the region are perpetually at the bottom of national district league tables. Achieving MDG Targets for Maternal and Neonatal became an emergency as 2015 drew close. Access to and utilization of quality maternal services are crucial to reducing maternal mortality. We explore the effects of multiple innovations on facility deliveries and demonstrate the associated reduction in health unit maternal deaths.

## Approaches

This study reviewed records on deliveries and maternal deaths at health facilities January 2013- March 2015. UNICEF-CUAMM project supported district health units to implement multiple innovations to accelerate access to and utilization of quality maternal and neonatal services. These included, a) transport voucher scheme, b) cultural adaptation of birth delivery using a birth cushion and transforming the role of traditional birth attendants, c) simplified maternity lighting using a simple solar suitcase, d) midwife mentors for mentoring, motivation and courage of young midwifes. Routine data from all 115 health units conducting deliveries from 2012 to March 2015 were collected. We used a before and after analysis to evaluate the effects of interventions. The key outcomes were facility deliveries and maternal death in health units.

## Results

Overall, deliveries increased by 95%, from 11,425(18% coverage) in 2012 to 22,271(47% coverage) in 2014. In 2014, 7,941 normal and complicated deliveries were transported using voucher. Increased deliveries were associated with declining institutional maternal deaths from 291/100,000 deliveries at the peak to 31 in quarter1 2015. The trend of deliveries was steeper in health units that received the birth cushion and cushion preference rose from 6% to 25% within 8 months of rollout. TBA deliveries decreased by 20.0% between 2012/2013 and by 42.1% between 2013/2014. 5/7 districts, showed significant increase total deliveries pushed by increase in night deliveries after solar suitcase, the best district nearly tripled monthly deliveries in supplied facilities. Facilities previously unable to conduct normal deliveries or emergency obstetric care were enabled to do so.

# Outcome materni e neonatali e valutazione della qualità delle cure ostetrico-neonatali nell'Ospedale San Luca di Wolisso, Etiopia


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## Obiettivi

Valutare l'impatto sugli outcome materni e neonatali delle attività di miglioramento conseguenti alla valutazione della qualità delle cure ostetrico-neonatali nell'ospedale San Luca di Wolisso in Etiopia, al fine di consolidare e migliorare ulteriormente tali servizi.

## Metodi

A fine 2009 è stata condotta una valutazione della qualità ostetrica e neonatale da parte di un team esterno di consulenti (un ginecologo, un neonatologo e un infermiera di sala parto), utilizzando uno strumento adattato ai paesi in via di sviluppo e sviluppato dall'OMS[1]. La misurazione è basata su questionari e osservazione diretta, con attribuzione di punteggi numerici alle varie dimensioni dell'assistenza ostetrica e neonatale, da cui si ricavano indicazioni specifiche di attività di miglioramento. Tali attività sono state completate nel 2011 con l'apertura di un'unità neonatale con 6 letti e attrezzatura specifica. È stato formato personale dedicato e introdotti strumenti di controllo e monitoraggio del neonato sano e patologico a partire dal punto nascita fino al ricovero e alla dimissione. È stata inoltre rafforzata l'assistenza ostetrica, il monitoraggio del parto e l'assistenza al neonato al momento del parto da parte di personale medico e infermieristico appositamente formato. A fine 2012 la valutazione è stata ripetuta con un punteggio complessivo della qualità valutata, passato da 1,72 a 2,46 su un massimo di 3. L'ospedale San Luca è l'unico per 4 distretti con una popolazione di 400.000 abitanti. Sono stati analizzati i dati di attività e di outcome dal 2011, raccolti dal sistema informativo dell'ospedale.

## Risultati

Dal 2011 sono 12.538 i parti assistiti e 2.201 i neonati patologici ricoverati di cui 948 nati a casa o nei centri di salute di riferimento dell'ospedale. Il trattamento delle complicanze ostetriche maggiori è aumentato dal 22 al 28% nei 4 anni considerati, mentre la mortalità per causa ostetrica maggiore sarebbe diminuita dall'1 allo 0,7%. Per quanto riguarda la mortalità perinatale resta intorno all'80 per mille nati, mentre quella dei nati morti, ma vivi al momento dell'inizio del parto/accesso in ospedale (fresh still birth), si sarebbe ridotta dal 40 al 5 per mille. Tutti questi dati sono riassunti nella tabella 1. Non c'è una differenza rilevante tra le mortalità dei neoanti nati in ospedale rispetto a quelli nati fuori e portati poi in ospedale, né una rilevante differenza e/o trend di riduzione o aumento. La differenza di mortalità è invece significativa confrontando la classe di neonati con peso > 2.5 kg e < 2.5 kg (rispettivamente 11% vs 29%).

[1] Making pregnancy safer: Assessment tool for the quality of hospital care for mothers and newborn babies, WHO Europe

Tra le cause di morte neonatale nel 2014 le prime 3 sono rispettivamente la sepsi (32%), l'immaturità (23,5%) e l'asfissia perinatale (22%). Quest'ultima come immaginabile rappresenta il più alto tasso di mortalità specifica (35,4%).

| | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| Totale parti in ospedale | 2.825 | 3.101 | 3.323 | 3.289 |
| Tasso mortalità da causa ostetrica maggiore | 1,0% | 0.7% | 0.5% | 0.7% |
| Tasso mortalità perinatale | 87 | 75 | 80 | 86 |
| Tasso mortalità nati morti "fresh still birth" | 42 | 9 | 14 | 5 |
| Totale neonati patologici ricoverati | 333 | 522 | 532 | 814 |
| Neonati patologici nati in ospedale | 197 | 363 | 315 | 378 |
| Tasso mortalità neonati nati in ospedale | 20% | 16% | 21% | 18% |
| Neonati patologi nati a casa/HC 136 159 217 436 | 136 | 159 | 217 | 436 |
| Tasso mortalità neonati nati fuori dall'ospedale | 16% | 11% | 15% | 23% |
| Tasso mortalità neonati >2,5Kg | n.d. | 14,6% | 11,2% | 11,6% |
| Tasso mortalità neonati <2,5Kg | n.d. | 29,8% | 30,5% | 29,1% |

## Conclusioni

La valutazione della qualità delle cure ostetrico-neonatali le conseguenti azioni e misure adottate migliorano i processi e l'organizzazione del servizio, documentati da un miglioramento dei risultati della valutazione stessa a distanza. Non sono state documentate rilevanti differenze di outcome, anche perchè il numero di casi e il tempo di implementazione e osservazione sono stati relativamente limitati. Il trend sembra comunque stabile o in riduzione. Si auspicano interventi più consistenti su sepsi e asfissia perinatale in quanto essi possono essere implementati anche in contesti a risorse limitate.

# Is a woolen cap effective in maintaining normothermia in preterm infants during kangaroo care in low-income countries?


## Author

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## Introduction and objective

The days and weeks following childbirth – the postnatal period – is a critical phase in the lives of mothers and newborn babies. Most maternal and infant deaths occur during this time[1]. In this period, neonatal hypothermia is an important challenge associated with morbidity and mortality[2]. Hypothermia increases the newborn's metabolic requirements and is associated with hypoglycemia, hypoxia, and ultimately severe infections and newborn mortality[3]. Preventing neonatal hypothermia is important in high resource countries, but is of fundamental importance in low resource settings where supportive care is limited. For the postnatal care of the newborn, the World Health Organization (WHO) guidelines state: *"Appropriate clothing of the baby for ambient temperature is recommended. This means one to two layers of clothes more than adults, and use of hats/caps".* Whenever possible, KC is also strongly recommended for temperature maintenance[4]. Previous studies show that neonatal heat loss following delivery may be reduced or prevented by the application of simple woolen hats[5-7].On the other hand, also hyperthermia should be avoided[8]. Although WHO guidelines recommend the use of cap/hat during KC, the effect of the cap on neonatal temperature during the days and weeks following childbirth has not been previously studied. It's unknown whether covering the head of the neonate with a wool cap during KC may help temperature maintenance. The results of the present study will allow to understand whether the use of a cap during KC will be effective and safe. The aim of the present study will be to assess the effectiveness and the safety of a woolen cap in maintaining normothermia in low birth weight infants (LBWI) during KC.

## Material and methods

This is a multi-center, prospective, unblinded, randomized clinical trial of KC treatment with and without a woolen cap in LBWI that will be run through a collaboration of the Department of Women and Children Health, University of Padua and Doctors with Africa CUAMM, a nongovernmental- organization that works to strengthen healthcare services in Africa.

The study will be conducted in three hospitals that have different levels of healthcare in three African countries and three different attitude to Kangaroo Care (well established, medially established and not established yet) where Doctors with Africa CUAMM has ongoing projects on maternal-neonatal health.

They are:

- the Central Hospital of Beira in Mozambique, which is a governmental hospital (III level);
- the St. Luke Wolisso Hospital in Ethiopia, which is a not-for-profit zonal hospital (II level);
- the Aber Hospital in Uganda, which is a not-for-profit rural hospital (I level).

Inclusion criteria for the study are

1. birth weight <2500 g (and)
2. candidate to KC treatment (and)
3. parental consent; a written informed consent will be obtained by a member of the neonatal team involved in the study from a parent or guardian before KC treatment.

While twins, patients with major congenital malformations, or babies with parental refusal to participate to the study, will be excluded.

The study will enroll a total number of 400 patients who will be randomly assigned to KC + cap or KC group without cap in a 1:1 ratio according to a computer-generated, randomized sequence. The primary outcome measure will be the time spent by the neonate in the normal temperature range (36.5-37.5°C) in course of KC during the first week of life. In all participants, axillary temperature will be measured with a digital thermometer 4 times per day. For each patients will also be estimated the number of hours spent in KC. While secondary variables will be: number of episodes of apnea, sepsis, mortality before hospital discharge, in-hospital growth and age at discharge.

## Expected results

In this trial, we expect to assess the efficacy and the safety of using a woolen cap during KC treatment. We also expect to detect differential effect of using woolen caps stratified for the number of hours spent in KC by patients.

## Discussion

There are unique features of this trial compared to prior studies on KC. World Health Organization guidelines recommend the use of a cap during KC treatment, but evidence for this practice is still lacking.

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[7] Lang N, Bromiker B, Arad I. The effect of wool vs. cotton head covering and length of stay with the mother following delivery on infant temperature. *International J Nursing Studies* 2004; 41:843–846.

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# MATERNAL AND CHILD HEALTH

## POSTER PRESENTATIONS

**IV congresso nazionale di cure del neonato nei paesi a limitate risorse**

- **Place of presentation**
  University of Milano - Italy
- **Date of presentation**
  13th October 2015
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MISCELLANEOUS

# DOCTORS WITH AFRICA CUAMM

# IS A WOOLEN CAP EFFECTIVE IN MAINTAINING NORMOTHERMIA IN PRETERM INFANTS DURING KANGAROO CARE?


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## BACKGROUND

The days and weeks following childbirth is a critical phase in the lives of mothers and newborn babies. Most maternal and infant deaths occur during this time.

In this period, **neonatal hypothermia is an important challenge associated with morbidity and mortality.**

Previous studies show that neonatal heat loss following delivery may be reduced or prevented by the application of simple woolen hats. On the other hand, also hyperthermia should be avoided.

Although WHO guidelines recommend the use of cap/hat during Kangaroo Care (KC), the effect of the cap on neonatal temperature during the days and weeks following childbirth has not been previously studied. It's unknown whether covering the head of the neonate with a wool cap during KC may help temperature maintenance. The results of the present study will allow to understand whether the use of a cap during KC will be effective and safe.

## METHODS

**Aim**
To assess the effectiveness and the safety of a wool cap in maintaining normothermia in LBWI during KC.

**Settings**
Four hospitals in 4 African countries where Doctors with Africa CUAMM has ongoing projects on maternal-neonatal health


**Design**
This is a multi center, prospective, unblinded, randomized clinical trial of KC treatment with and without a wool cap in LBWI

**Outcome**
The primary outcome will be the time spent by the neonate in the normal temperature range (36.5-37.5°C) in course of KC during the first week of life


The protocol was approved by the local Ethics Committees for human investigation

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Doctors with Africa

## DISCUSSION

There are unique features of this trial compared to prior studies on KC. World Health Organization guidelines recommend the use of a cap during KC treatment, but evidence for this practice is lacking. In this trial, we will assess the efficacy and the safety of using a wool cap during KC treatment.

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- Day R, Caliguiri I, Kamenski C, Ehrlich F. Body temperature and survival of premature infants. *Pediatrics* 1964; 34:171-181.
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**18° Congresso Nazionale della società italiana di Medicina Perinatale - Verso un'ecologia perinatale,**

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# DOCTORS WITH AFRICA CUAMM

# DETERMINATION OF HEART RATE IN INFANTS NEEDING RESUSCITATION AT BIRTH - METHOD COMPARISON IN A LOW INCOME COUNTRY


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## INTRODUCTION AND OBJECTIVE

Intrapartum-related events, previously called "birth asphyxia", account for a quarter of neonatal deaths.[1]
Initial assessment of breathing and heart rate (HR) is an essential part of newborn resuscitation.[2]
The International Guidelines for Neonatal Resuscitation state that auscultation of the precordium should remain the primary means of assessing HR.[2]
Although based on a very low quality of evidence, recent literature suggests that electrocardiogram (ECG) can be used to provide a rapid and accurate estimation of HR..[3,4]
Algorithms for neonatal resuscitation adapted to low resource settings include HR evaluation by auscultation or umbilical cord palpation at about one minute of life.[5-7]
In low resource countries, a stethoscope is rarely available and HR is routinely detected by palpation of the umbilical pulse.
Although this is preferable to other palpation sites (i.e. femoral and brachial artery), there is a high likelihood of underestimating HR with palpation of the umbilical pulse in healthy infants.[8,9]
Previous studies conducted in manikins and healthy infants showed that about half of the times HR detection methodology is wrongly executed.[8,10]
Our hypothesis is that palpation of the umbilical cord could further underestimates HR when used in neonates with bradycardia. The accuracy of clinical HR assessment in infants needing resuscitation at birth remains to be determined.
This study was designed compare two different methods (auscultation and umbilical cord palpation) of HR estimation in newborn infants needing resuscitation, in order to determine which method is most suitable for use in clinical practice.

## MATERIALS AND METHODS

This is a single centre, prospective, randomized clinical trial comparing two methods for assessing HR in infant newborns needing resuscitation at birth. The study will be conducted at the Central Hospital of Beira in Mozambique (5.555 deliveries - CUAMM data 2013), which is a governmental hospital (III level) (Mozambique: neonatal deaths, 34% of all under-5 deaths; neonatal mortality rate: 30 per 1000 live births; source: *Countdown to 2015, The 2014 Report*).[11] This study will be part of a collaborative project between the Beira Central Hospital and Doctors with Africa CUAMM, a non-governmental organization.[12]

Infants satisfying the following inclusion criteria (being born infants, needing for resuscitation and with parental informed consent signed) will be eligible to participate in the study.

Patients with major congenital malformations or without parental informed consent will be excluded from the trial.

The sample size could not be estimated using mathematical methods because of the lack of data about accuracy in HR estimation by auscultation and umbilical palpation in newborn infants needing resuscitation. Therefore, we plan to enrol 60 subjects (30 in the stethoscope group and 30 in the palpation group) according to a previous study on healthy infants at birth.[9]

Eligible infants will be randomly assigned to auscultation or palpation group in a 1:1 ratio according to a computer-generated, randomized sequence.

The primary outcome measure will be the degree of agreement as regards the categorisation of the HR obtained by auscultation or palpation compared with the HR as determined by ECG. The HR - beats per minute (bpm) - will be categorised as either not palpable, <60, 60–100 or >100 bpm. The values of 60 and 100 bpm were chosen as they are recommended in the guidelines for determining the need to intervene. 2,6,7 HR will be detected at 60, 90, 120 seconds and at 5 minutes of life. Among secondary outcomes will be evaluated mortality, severe asphyxia, age at discharge.

The degree of agreement between categorical HR by auscultation and by ECG will be evaluated using Cohen's Kappa coefficient, with a value greater than 0.8 indicating good agreement. The same approach will be used to evaluate the agreement between umbilical cord palpation and ECG. The two Kappa coefficients will be compared using the test for equal Kappa coefficients, that under the null hypothesis of equal coefficients in the two groups has an asymptotic chi-square distribution with 1 degree of freedom. A p-value less than 0.05 will be considered significant. Categorical data will be expressed as number and percentage and compared using Fisher test. Continuous data will be expressed as mean and standard deviation or median and interquartile range (IQR). Normality assumption of continuous variables will be evaluated using Shapiro-Wilk test. Continuous data will be compared using Student t test or Mann-Whitney non parametric test. Correlation between continuous data will be evaluated using Pearson correlation coefficient or Spearman correlation coefficient. Statistical analysis will be performed using R 2.12 language.

## EXPECTED RESULTS

In this trial, we will compare the accuracy of assessing HR in neonates needing resuscitation at birth by the two recommended methods. The findings of this study will be important for other units/settings in high as well low resource countries where HR estimation is routinely done by auscultation and/or palpation.

## DISCUSSION

There are unique features of this trial compared to prior studies on HR assessment of neonates at birth. World Health Organization guidelines recommend to detect HR by auscultation and/or palpation, but evidence for this practice is lacking. Based on the results of the present study, we could speculate whether the availability of a stethoscope is mandatory for management of neonates needing resuscitation at birth.

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**IV congresso nazionale di cure del neonato nei paesi a limitate risorse**

- **Place of presentation**
  University of Milano - Italy
- **Date of presentation**
  13th October 2015
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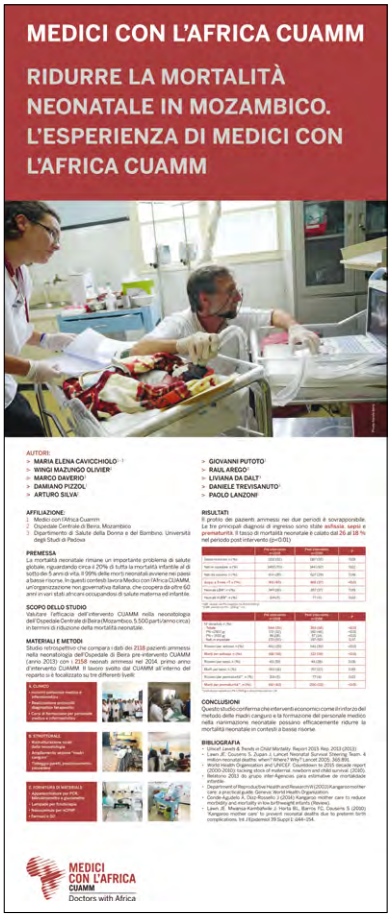
MOZAMBIQUE


MEDICI CON L'AFRICA CUAMM

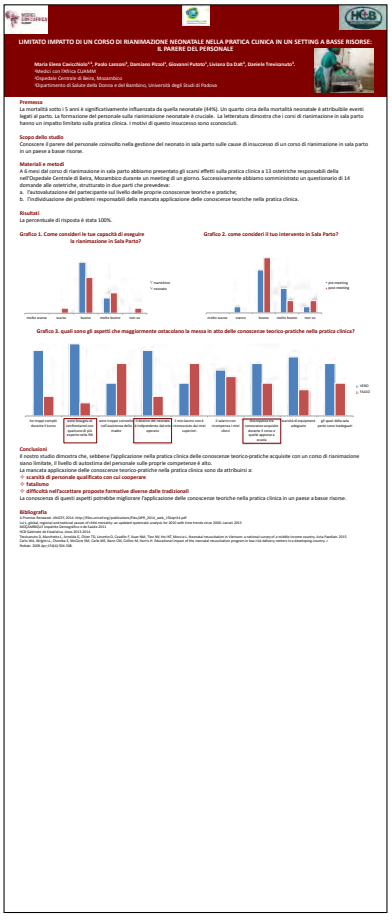
APLASIA CUTANEA CONGENITA A BEIRA, MOZAMBICO: UN CASE REPORT IN UN CONTESTO A RISORSE LIMITATE


DOCTORS WITH AFRICA CUAMM

IS A WOOLEN CAP EFFECTIVE IN MAINTAINING NORMOTHERMIA IN PRETERM INFANTS DURING KANGAROO CARE?


MEDICI CON L'AFRICA CUAMM

RIDURRE LA MORTALITÀ NEONATALE IN MOZAMBICO. L'ESPERIENZA DI MEDICI CON L'AFRICA CUAMM


LIMITATO IMPATTO DI UN CORSO DI RIANIMAZIONE NEONATALE NELLA PRATICA CLINICA IN UN SETTING A BASSE RISORSE: IL PARERE DEL PERSONALE

## XV Giornate di Salute di Maputo

- **Place of presentation**
  Maputo - Mozambique
- **Date of presentation**
  16th-18th September 2015
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MOZAMBIQUE

## MÉDICOS COM ÁFRICA CUAMM

# CONTRIBUIÇÃO DO MÉTODO DE GRAVAÇÃO DE VÍDEO PARA A MELHORIA DA QUALIDADE DA REANIMAÇÃO NEONATAL. A EXPERIENCIA DO HOSPITAL CENTRAL DA BEIRA (HCB)


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> **FEDERICA BERTUOLA**, UNIVERSIDADE DE PÁDUA & GIOVANNI PUTOTO, MÉDICOS COM AFRICA CUAMM


### INTRODUÇÃO

Os eventos relacionados com o parto são responsáveis por cerca de 20% da mortalidade neonatal no mundo. A melhoria da assistência ao nascimento pode reduzir a mortalidade neonatal. O objectivo deste estudo foi de avaliar, através da utilização de gravação de vídeo, o desempenho dos operadores na sala de parto, antes e após dum curso de reanimação neonatal, num contexto com baixos recursos.

### METODOLOGIA

O estudo, realizado no HCB desde 11.01.2013 até 06.03.2014, foi realizado em 3 fases: 1) um período basal no qual foram gravadas 50 reanimações neonatais, 2) um período de intervenção (curso de reanimação neonatal), 3) um período de pós-intervenção no qual foram gravadas outras 50 reanimações. As intervenções de ressuscitação foram gravadas através do uso de filmadora e avaliadas com base numa pontuação validada.

### RESULTADOS

Após o curso, houve uma melhoria significativa na pontuação em todas as fases da ressuscitação: "os passos iniciais da reanimação" (mediana 33%, IQR 28%-39% vs mediana 44%, IQR 39%-56%, p<0.0001); "a ventilação com balão e máscara" (mediana 20%, IQR 20%-40% vs 40%, IQR 40%60%, p=0.001), "as compressões torácicas" (mediana 0%, IQR 0%-10% vs 20%, IQR 0%-50%, p=0.01). O início da intervenção de ventilação estava acelerado significativamente entre antes e após do curso (mediana 21 segundos, IQR 0-72 vs 10 segundos, IQR 0-29) mas os tempos de execução dos procedimentos de reanimação estavam atrasados em relação às recomendações oficiais. Não foram encontradas diferenças sobre aos resultados clínicos (mortalidade, diagnóstico de alta, duração da estadia) entre os dois grupos.

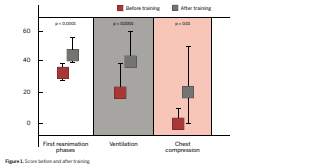


Figure 1. Score before and after training

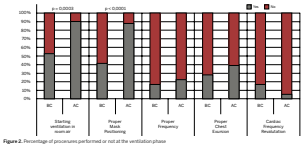


Figure 2. Percentage of procedures performed or not at the ventilation phase

### CONCLUSÕES

Este estudo avalia, pela primeira vez com a técnica da gravação em vídeo, a intervenção na sala de parto antes e após dum curso de reanimação neonatal num contexto com baixos recursos. Os resultados mostram que, apesar do que alguns aspectos sejam melhorados, a intervenção global permanece abaixo dos padrões recomendados para a qualidade e para os prazos de execução. As razões deste impacto limitado na prática clínica precisam de ser aprofundada. Estes resultados fornecem a base para o planeamento das intervenções futuras na área da assistência neonatal em países com baixos recursos.


**Palavras chave**: reanimação neonatal, gravação em vídeo, países com baixos recursos.


MEDICI CON L'AFRICA CUAMM Doctors with Africa



## MÉDICOS COM ÁFRICA CUAMM

# CUIDADOS OBSTÉTRICOS DE EMERGÊNCIA NO DISTRITO DA CIDADE DA BEIRA


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> **G. PUTOTO**, MÉDICOS COM ÁFRICA CUAMM (ITÁLIA)
> **L. BRUMANA**, UNICEF MOÇAMBIQUE
> **D. MAHOTAS**, UNICEF MOÇAMBIQUE
> **C. FARNELA**, SDSMAS
> **M. ROMANELLI**, MÉDICOS COM ÁFRICA BEIRA (MOÇAMBIQUE)
> **M. MELO**, MÉDICOS COM ÁFRICA BEIRA (MOÇAMBIQUE)
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> **ARTURO SILVA**, MÉDICOS COM ÁFRICA BEIRA (MOÇAMBIQUE)


### INTRODUÇÃO

Apesar das melhorias recentes nos indicadores materno-infantis em Moçambique, a taxa de mortalidade materna continua a ser elevada (408/100.000 nascidos vivos). Evidências sugerem que nos países em desenvolvimento apenas o acesso ao parto institucional não é suficiente para reduzir a mortalidade materna. Sãs os Cuidados Obstétricos de Emergência (COEm) de qualidade que são fundamentais para salvar a vida de mães e recém-nascidos quando ocorrem complicações e a maneira mais eficaz de alcançar o quinto ODM. Beira é a segunda maior cidade de Moçambique (457.799 habitantes), com uma taxa de parto institucional de mais de 95%. O objectivo do estudo foi determinar a presença e utilização dos serviços de COEm, neste contexto.

### METODOLOGIA

Um estudo transversal das 10 Unidades de Saúde (USs) com maternidades e HCB no Distrito de Beira durante 2013. Os dados foram colectados através de entrevista pessoal e revisão de registos. As funções vitais de COEm avaliadas foram 9: 6 básicas (administração intravenosa de antibióticos, administração intravenosa de ocitocina, administração das anti convulsivantes, remoção manual da placenta, remoção dos produtos retidos e parto vaginal assistido) e 3 avançadas (reanimação neonatal com bolsa e máscara, transfusão de sangue e cesariana).

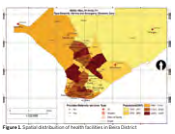

Figure 1. Spatial distribution of health facilities in Beira District

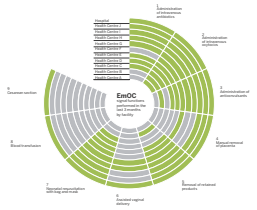


Figure 2. EmOC signal functions performed in the last 3 months by facility

### RESULTADOS

O número de instalações com serviços COEm por 500.000 habitantes foi de 1, contra as 5 recomendadas pela ONU. Apenas o hospital (HCB) havia realizado todas as nove funções. Nenhum US tinha realizado todas as seis funções básicas COEm. Parto vaginal assistido e remoção manual da placenta foram as funções mais frequentemente ausentes, realizadas apenas por 2 e 3 USs respectivamente. A resposta a demanda de COEm foi de 35,6%, a proporção de todos os nascimentos com serviços COEm foi de 27%, e 11,3% dos partos esperados foram por cesariana. A taxa de letalidade obstétrica foi de 3,1%, três vezes mais elevada do que o nível aceitável. A proporção de mortes maternas por causas indirectas dos serviços COEm foi de 37,9%.

### CONCLUSÕES

O Distrito da Beira tem uma alta cobertura de parto institucional, mas existem lacunas na disponibilidade, uso e qualidade dos serviços COEm, mesmo aqueles considerados básicos. Consequentemente o alcance da redução da mortalidade materna e infantil vai continuar a ser incerto no distrito. É necessário um esforço imediato e comum para melhorar os COEm e combater este "Flagelo" evitável.


**Palavras-chave**
Mortalidade Materna-Neonatal, Qualidade dos Serviços COEm.


MEDICI CON L'AFRICA CUAMM Doctors with Africa

**IV congresso nazionale di cure del neonato nei paesi a limitate risorse**

- **Place of presentation**
  University of Milano - Italy
- **Date of presentation**
  13th October 2015
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SIERRA LEONE

# MEDICI CON L'AFRICA CUAMM

# LA SFIDA PER LA SALUTE MATERNO-INFANTILE AI TEMPI DI EBOLA IN SIERRA LEONE


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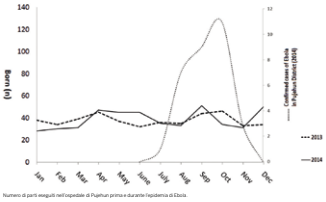
**INTRODUZIONE**
L'epidemia di Ebola scoppiata in Africa occidentale a dicembre 2013 ha causato, sulla base del report dell'Organizzazione Mondiale della Sanità (OMS), in Sierra Leone quasi quattromila morti tra gli oltre 13 mila casi riportati. Unicef ha stimato che la mortalità dei bambini sotto i cinque anni, per le cause dirette ed indirette dell'interruzione dei servizi legati a tale epidemia, ha subito un incremento del 20% con ulteriori 8.593 morti rispetto ai 39.204 bambini deceduti. Anche la salute materna è stata duramente colpita dagli effetti dell'epidemia con oltre 300 decessi materni correlati a Ebola che vanno ad aggiungersi ai già 1.781 segnando un incremento del 19%. Una delle maggiori sfide durante l'epidemia è stata quella di mantenere i servizi di salute materno infantile in un contesto a risorse limitate e con costi elevatissimi per raggiungere l'obiettivo principale di arginare e debellare il virus.
Medici con l'Africa Cuamm è una Ong italiana che opera in Africa da oltre 60 anni con progetti a medio-lungo termine ed è presente in Sierra Leone, nel distretto di Pujehun, dal 2012 con un programma per migliorare e rafforzare i servizi per la salute materno-infantile.

**MATERIALI E METODI**
L'11 luglio 2014 nel distretto di Pujehun è stato registrato il primo caso confermato di Ebola e sono state quindi attivate le misure per il controllo dell'epidemia in termini di prevenzione, gestione dei casi e sorveglianza. In particolare, per quanto riguarda le attività di prevenzione sono stati avviati corsi di formazione, forniti equipaggiamenti di protezione per il personale e promosso campagne di sensibilizzazione nella comunità; inoltre è stata rivista la gestione delle risorse umane impiegate nel campo senza ridurre l'offerta sanitaria. Infine, da un punto di vista operativo è stata organizzata una risposta rapida all'infezione, allestito un centro di isolamento per la gestione dei casi clinici e un servizio di gestione in sicurezza dei cadaveri e coordinato un servizio di triage, mappatura dei contatti e quarantena.

MEDICI CON L'AFRICA CUAMM
Doctors with Africa

**RISULTATI**
Nel 2014 i ricoveri nel reparto di Pediatria hanno registrato un forte calo a giugno in corrispondenza dei primi casi di Ebola registrati in Sierra Leone. La riduzione dei ricoveri pediatrici è quasi significativa nel periodo luglio-dicembre passando da 424 nel 2013 a 312 nel 2014 (p 0,05). I ricoveri nel reparto Maternità sono stati 716 nel 2014 (nel 2013 erano stati 781, p 0,07) senza differenze statisticamente significative. Il numero totale di parti registrati nell'ospedale di Pujehun è stato di 460 nel 2014 (453 nel 2013, p 0,41), con una sensibile riduzione tra giugno e agosto, prima di riassumere un trend positivo.



Numero di parti eseguiti nell'ospedale di Pujehun prima e durante l'epidemia di Ebola.

**DISCUSSIONE**
L'epidemia di Ebola ha ridotto il numero dei pazienti che hanno usufruito dei servizi sanitari in ambito materno e infantile, tuttavia, una pronta risposta nella gestione dell'emergenza ha permesso di mantenere i servizi riducendo al minimo la diffusione dell'infezione e l'impatto dell'epidemia stessa sulle attività sanitarie di routine mantenendo alta la fiducia della popolazione nel servizio sanitario locale. Tale risultato è stato possibile grazie a molteplici fattori alcuni sanitari altri contestuali quali una chiara leadership locale per la gestione dell'emergenza e il coinvolgimento della comunità stessa.
In conclusione, la nostra esperienza in ambito materno infantile ci permette di fare le seguenti riflessioni: I) Le conseguenze indirette dell'epidemia risultano maggiori dei danni causati dall'epidemia in sé; II) è d'obbligo agire il più tempestivamente possibile soprattutto in contesti a risorse limitate; III) è fondamentale un approccio multi fattoriale e non legato solo alla crisi dell'emergenza anche al fine di mantenere la fiducia della popolazione nei confronti dei servizi sanitari; IV) la collaborazione con le autorità locali e la società civile risulta cruciale per sviluppare, applicare e controllare nel modo più appropriato gli interventi sanitari.
Ci auguriamo che questi approcci possano essere di aiuto e allo stesso tempo migliorati anche dagli altri operatori, e auspicabilmente in collaborazione con loro, soprattutto nei contesti più difficili e a risorse limitate.

**Call to action summit - Ending preventable Maternal and Child Deaths**

- **Place of presentation**
  New Delhi - India
- **Date of presentation**
  27th and 28th August 2015
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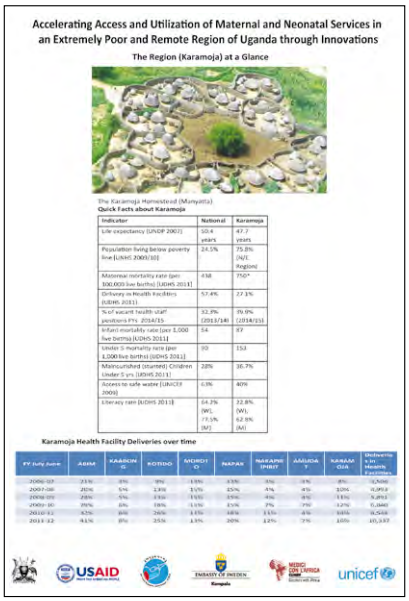
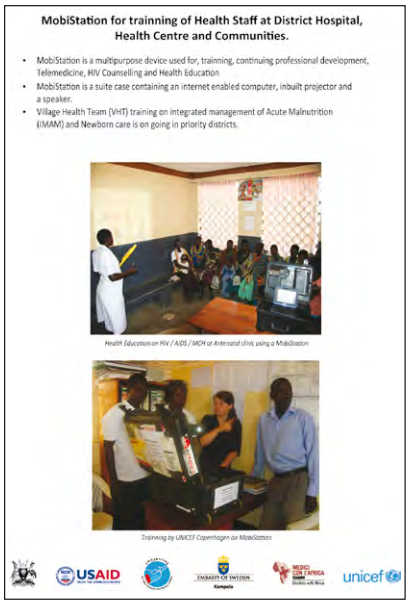
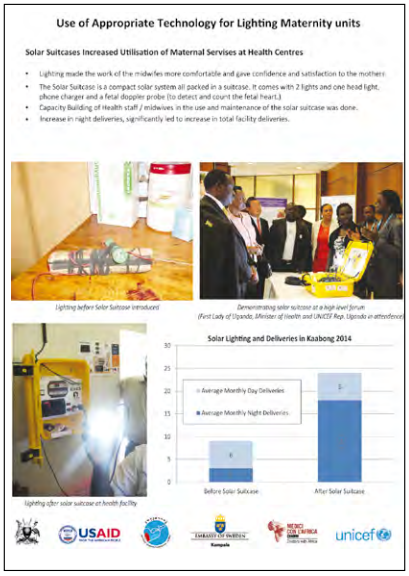
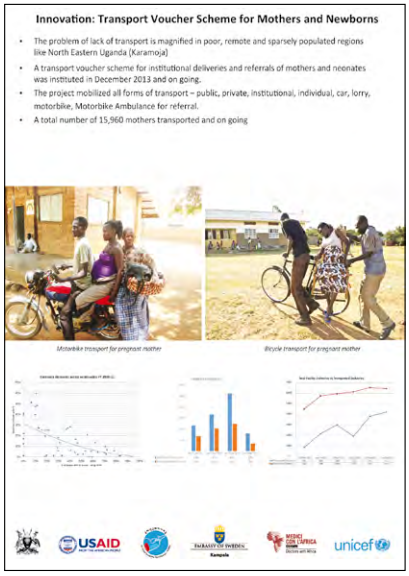
UGANDA





# Infectious and Tropical Diseases

## Papers

# INFECTIOUS AND TROPICAL DISEASES

## PAPERS

# Predictors of treatment failure in HIV-positive children receiving combination antiretroviral therapy: cohort data from Mozambique and Uganda


- **Authors**
  Costenaro P., Penazzato M., Lundin R., Rossi G., Massavon W., Patel D., Nabachwa S., Franceschetto G., Morelli E., Bilardi D., Nannyonga M. M., Atzori A., Mastrogiacomo M. L., Mazza A., Putoto G., Giaquinto C.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The increase in treatments for people affected by HIV virus has led to a global reduction of new childhood infections. Nonetheless, particularly in settings with limited resources, the level of emergency is still high, despite the efforts to expand access to combined antiretroviral therapy (cART), One of the main causes of the still high percentage of HIV-infected children is delay in identifying treatment failure to then go to the second line of treatment. This delay causes drug resistance and a resulting overall difficult in combating the infection.

Starting from a comparative analysis of therapies implemented in hospitals in Beira, Mozambique and Nsambya, Uganda between 2005 and 2009 with the support of the NGO Doctors for Africa CUAMM and the Associazione Casa Accoglienza alla Vita Padre Angelo, the authors of the article, published in 2014 in the Journal of the Pediatric Infectious Diseases Society, sought to identify cART failure predictors in children in two situations.

Treatment failure is due to factors such as being simultaneously infected with tuberculosis or other WHO stage 4 defining diseases. Reasons for delay in moving to the second line of treatment are difficult to identify, which is to say that it is not clear if the responsibility lies with the healthcare personnel or if it is objectively difficult to identify failures. There are also differences between the two countries, such as the age of the children, the stage of the disease and number of visits. Nonetheless, the conclusion the authors reach by presenting data collected is essential for simplifying clinical and immunological criteria to identify treatment failures and move quickly to the next stage. This is the only way to increase cART effectiveness.

# Predictors of Treatment Failure in HIV-Positive Children Receiving Combination Antiretroviral Therapy: Cohort Data From Mozambique and Uganda

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**Background.** Delays detecting treatment failure and switching to second-line combination antiretroviral therapy (cART) are often observed in human immunodeficiency virus (HIV)–infected children of low-middle-income countries (LMIC).

**Methods.** An observational study included HIV-infected children attending the Beira Central Hospital (Mozambique) and the Nsambya Hospital, Home Care Department (Uganda) evaluated clinical and immunological failure according to World Health Organization (WHO) 2006 guidelines. Baseline predictors for cART failure and for drug substitution were explored in unadjusted and adjusted Cox proportional hazard models.

**Results.** Two hundred eighteen of 740 children with at least 24 weeks follow-up experienced treatment failure (29%; 95% confidence interval [CI] 26–33), with crude incidence of 20.0 events per 100 person-years (95% CI 17.5–22.9). Having tuberculosis co-infection or WHO stage 4, or starting a nontriple cART significantly increased risk of failure. Two hundred two of 769 (26.3%) children receiving cART substituted drug(s), with crude incidence of 15.4 events per 100 person-years (95% CI 13.4–17.7). Drug toxicity (18.3%), drug availability (17.3%), and tuberculosis drugs interaction (52, 25.7%) were main reported reasons, while only 9 (4%) patients switched cART for clinical or immunological failure. Children starting lamivudine-zidovudine-nevirapine or lamivudine-stavudine-efavirenz or lamivudine-zidovudine-efavirenz were more likely to have substitute drugs. Increased substitution was found in children with mild immunosuppression and tuberculosis co-infection at cART initiation as well as poor adherence before drug substitution.

**Conclusions.** Considerable delay in switching to second-line cART may occur despite an observed high rate of failure. Factors including WHO clinical stage and tuberculosis co-infection should be evaluated before starting cART. Toxicity and drug adherence should be monitored to minimize drug substitution in LMIC.

**Key words.** children; drug substitution; HIV; treatment failure.

## BACKGROUND

The global scaling up of treatment and care for people living with human immunodeficiency virus (PLWH) has led to a 43% decline in new HIV pediatric infections since 2003, with 330,000 newly infected children in 2011. Despite efforts to expand access to combination antiretroviral therapy (cART), only 28% of eligible children have received it [1]. Expansion of early HIV diagnosis coverage, prompt cART initiation, and better retention in care remain major goals [2, 3], and the lack of laboratory monitoring frequently observed in low and middle-income countries (LMIC) should not represent a barrier to cART distribution in children [4]. However, optimization of the clinical management of PLWH and prompt diagnosis of treatment failure are becoming increasingly critical in the context of lifelong treatment and limited drug availability.

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Although virological failure is widely considered the criterion standard to detect treatment failure, clinical and immunologic parameters are often the only criteria available in LMIC [5, 6]. CD4 cell monitoring has been shown to be a poor predictor of virological failure in treatment-experienced children [7–9], particularly when severely immune-compromised [10]. Studies in LMIC have reported high rates of virological suppression in children up to 5–6 years after treatment initiation [11, 12]; however, treatment failure rates of 10–34% were observed among children after 2–3 years of cART [13–18]. Program reports suggest that only a small proportion of patients on treatment are receiving a second–line therapy, an estimated 4% of adults and 1–14% of children [16, 18–20]. Delays in detecting treatment failure and switching to second-line therapy lead to the development of HIV drug-resistance, compromising subsequent regimens [6, 21]. This is particularly relevant for children, due to the lack of pediatric formulations.

Randomized trials were conducted to evaluate the optimal first antiretroviral regimen for reducing the risk of treatment failure. Findings from the P1060 trial reported an increased risk of failure starting a nevirapine (NVP)-based cART in infants and young children [13, 22, 23]. This was not confirmed by the PENPACT1 trial, where no difference in clinical and virological outcomes were shown between non-nucleoside reverse-transcriptase inhibitors (NNRTI) and protease inhibitors (PI)–based regimens in older children [24]. Data to inform the most durable nucleoside reverse-transcriptase inhibitors (NRTI) backbone in the context of a triple therapy is still limited. Conflicting results were reported concern the use of abacavir (ABC) as first-line regimen: Green et al. suggested that abacavir (ABC) may be preferable to zidovudine (AZT) combination with lamivudine (3TC) [25], while poorer early virological outcomes were recently observed in children starting ABC/3TC-based first-line regimens, compared to stavudine (d4T)/3TC [26, 27]. Identifying optimal regimens is particularly relevant for children with HIV/tuberculosis (TB) co-infection living in LMIC, where NVP is widely preferred to efavirenz (EFV) or a triple NRTI-based regimen, due to its better acceptability and relatively low cost [28].

Drug substitution is often required to optimize antiretroviral treatment [19, 29]. Results from observational studies estimate a probability of cART discontinuation or modification ranging between 2.8% and 20% in adults of LMIC [19, 30–34]. A randomized study conducted in children shows a cART switching/discontinuation rate up to 29% [24]. Acute and chronic toxicity, drug intolerance, poor adherence, and treatment failure remain the major determinants of cART modification [35–38]. Drug costs and/or being out of stock due to challenges in adequately forecasting and maintaining an effective supply chain have been cited as further reasons for cART discontinuation in LMIC [31, 33].

The aim of this study is to estimate the rate and predictors of cART treatment failure in 2 pediatric cohorts from Mozambique and Uganda during a 5-year follow-up period, and to explore the rate of and factors associated with drug substitution.

## METHODS

### Setting and Study Design

We conducted a retrospective cohort study among children starting cART between January 2005 and December 2009 at the Beira Central Hospital (HCB) in Mozambique and the Nsambya Home Care (NHC) department of St. Raphael of St. Francis Hospital in Uganda. Two Italian nongovernmental organizations, Doctors with Africa Cuamm (Mozambique) and Associazione Casa Accoglienza alla Vita Padre Angelo (Uganda), partnered with these hospitals to provide pediatric HIV care.

Both programs provided HIV counseling and testing, cotrimoxazole prophylaxis, cART, laboratory investigations, and management of opportunistic infections. Infants and children under 18 months of age, known or suspected to be exposed to HIV, were diagnosed through HIV-1 DNA testing. Patients were considered eligible for cART according to WHO 2006 guidelines [39].

Laboratory examinations including full blood count, liver function tests, creatinine, and CD4 count were required before starting cART, as well as a chest radiograph and acid-fast bacilli testing to exclude TB if suspected. In the absence of contraindications, written consent was collected when enrolling in the programme and before starting cART. Throughout the study, patients were switched to second-line cART when treatment failure was identified following WHO 2006 guidelines [39].

The study was approved by the ethics committees of HCB and Nsambya Hospital and registered by the Uganda National Council for Science and Technology and by the Gabinete Do Director Gerar, Ministerio Da Saudè of HCB (Mozambique).

**Data Collection.** In Mozambique, data were collected from clinical charts and paper registries and entered in the hospital's electronic patient database system. Similarly, in Uganda, routine clinical data were recorded in paper-based patient files and registries and entered into an electronic interface by trained staff.

Children were examined at least monthly during the first 6 months of cART and then every 3 months in Mozambique, while in Uganda monthly visits were

maintained throughout the follow-up according to the project design. Weight and height were measured at every clinic visit. Full blood count, liver function tests, and glucose assays were performed every 6 months, and CD4 counts every 6–12 months. Adherence to cART was assessed at every follow-up visit and defined as "good" or "poor" if the self-reported number of doses was more or less than 95% of expected monthly number of doses. HIV-related clinical events were diagnosed with or without biological confirmation, depending on lab facilities available, while immunodeficiency was classified as mild, advanced, and severe according to the WHO 2006 thresholds [39]. For the treatment failure analysis, the period of follow-up was from cART initiation up to the treatment failure outcome, while follow-up was from treatment initiation to first cART drug substitution for drug-substitution analysis. For children without treatment failure or drug substitution, follow-up was censored at date of death, loss to follow-up (LTFU, defined as missing follow-up visits for more than 6 months), transferred to other clinic, confirmed HIV-negative or aged more than 18 years old, last CD4 measurement, or last anthropometric or adherence record, whichever occurred latest.

**Endpoint Definitions and Study Population.** Drug-substitution was defined as substitution of one or more drugs of the first antiretroviral regimen for any reason. Reasons for drug substitution were classified retrospectively from the inspection of what was reported by clinicians in patient's clinical charts. Clinical and immunological failure were defined according to the WHO 2006 criteria, using CD4 measurements and WHO disease stage from at least 24 weeks after cART initiation [39]. Treatment failure, when both clinical and immunological failures were observed, was considered to occur at the earliest of the two events.

For analysis of treatment failure, only children with at least 24 weeks of follow-up post-cART initiation were included to ensure sufficient time for treatment response.

For analysis of cART drug substitution, children who received an ABC component in their initial cART regimen were excluded, as first-line ABC treatment was systematically administered to children diagnosed with active TB and all patients initially on ABC were routinely switched to EFV once the TB infection cleared.

**Statistical Analyses.** In this intent-to-treat analysis, all children were included from cART initiation, regardless of subsequent modifications. All analyses were conducted in R version 2 (R Development Core Team, Vienna, Austria) and Stata version 12.0 (Stata Corporation, College Station, TX).

For both treatment failure and drug-substitution analyses, frequency distributions and median and interquartile range (IQR) were used to describe baseline patient characteristics. Baseline characteristics of interest were gender, age at treatment initiation, body–mass index (BMI, weight[kg]/height$^2$[m]) for age z-score, WHO disease stage, initial cART treatment regimen (also by most potent component), adherence to cART, CD4 count and percent, and immunodeficiency classification. All descriptive analyses were stratified by hospital. Differences in all key variables at baseline between these strata were determined using Pearson's $\chi^2$ test for categorical variables, the *t*-test for difference in means for baseline BMI for age z-score, and the Wilcoxon rank-sum test for all other continuous variables.

Unadjusted Cox proportional hazards models were used to determine the odds of treatment failure and cART drug substitution. The following variables were considered in a multivariate adjusted Cox proportional hazards model of treatment failure: cART treatment regimen, age, adherence, gender, country of treatment, baseline disease stage, immunodeficiency status, and BMI for age z-score. The following variables were considered in a multivariate adjusted Cox proportional hazards model of cART drug substitution: cART treatment regimen, adherence, classification of immunodeficiency status, WHO disease stage, and age group. A backward-selection procedure was used to create these adjusted models, with a variable being included in the model if it resulted in an improvement in the model fit as defined by the Akaike Information Criterion (AIC).

## RESULTS

Between January 2005 and December 2009, 1075 HIV-infected children less than 15 years old began cART in HCB and NHC. Two hundred thirteen (20%) children were excluded from the study due to missing data (Table 1). Children excluded from both treatment-failure and drug-substitution analyses were more likely to be Ugandan ($P < 0.01$), female ($P = 0.049$), younger ($P < 0.01$) and enrolled and starting cART later ($P < 0.01$ and $< 0.01$, respectively) than children included in the study.

### Treatment Failure Analyses

Among 862 children eligible for analysis, 740 children (492 from Mozambique and 248 from Uganda) with at least 24 weeks of follow-up were included for a total of 1088.5 person/years of follow-up. At the time of data collection, 24/740 (3.24%) children died, 68 (9.19%) were LTFU, 7 (0.95%) were transferred to another clinic, and 1 (0.14%) was confirmed HIV-negative. A total of 218 treatment failure events (29%; 95% CI 26–33) occurred, with a crude incidence rate of 20.0 events per 100 person-years (95% CI 17.5–22.9). Median time to treatment

**Table 1.** Baseline Characteristics of 862 Children Included and 213 Children Excluded from Analyses Due to Missing Data

| Variable | Value | Included children n = 862 | Excluded children n = 213 (20%) | *P* value |
|---|---|---|---|---|
| Gender | Male | 449 (52) | 99 (46) | |
| | Female | 413(48) | 113 (53) | 0.049[a] |
| Country | Mozambique | 583 (68) | 102 (48) | |
| | Uganda | 279 (32) | 111 (52) | <0.01[a] |
| Year of birth | Median (IQR) | 2002 (1998–2005) | 2001 (1996–2005) | |
| | <1995 | 76 (9) | 34 (16) | 0.02[b] |
| | 1995-1999 | 219 (25) | 54 (25) | |
| | 2000-2004 | 289 (34) | 58 (27) | <0.01[a] |
| | 2005-2009 | 278 (32) | 59 (28) | |
| | missing | 0 (0) | 8 (4) | |
| Age at treatment initiation (years) | Median (IQR) | 4.83 (2.09–9.11) | 6.33 (2.62–11.56) | |
| | <12 months | 62 (7) | 11 (5) | <0.01[b] |
| | 12–35 months | 256 (30) | 48 (23) | |
| | 36–59 months | 120 (14) | 22 (10) | |
| | 5–8 years | 157 (18) | 40 (19) | <0.01[a] |
| | >8 years | 267 (31) | 92 (43) | |
| | Missing | 0 (0) | 8 (4) | |
| WHO clinical stage at treatment initiation | Stage I or II | 75 (9) | 14 (7) | |
| | Stage III with TB | 36 (4) | 11 (5) | |
| | Stage III w/o TB | 57 (7) | 22 (10) | |
| | Stage IV with TB | 10 (1) | 6 (3) | 0.14[a] |
| | Stage IV w/o TB | 47 (6) | 13 (6) | |
| | Unknown | 637 (74) | 147 (69) | |
| Age at enrollment (years) | Median (IQR) | 3.94 (1.48–8.09) | 5.57 (1.61–9.47) | |
| | Missing | 0 (0) | 8 (4) | 0.01[b] |
| Initial treatment regimen | 3TC + 4DT + NVP | 369 (43) | 70 (33) | |
| | 3TC + AZT + NVP | 231 (27) | 60 (28) | |
| | 3TC + AZT + EFV | 80 (9) | 35 (16) | |
| | 3TC + 4DT + EFV | 57 (7) | 15 (7) | |
| | 3TC + AZT + ABC | 48 (6) | 15 (7) | 0.06[a] |
| | Other triple | 68 (8) | 15 (7) | |
| | Other dual | 3 (0) | 1 (<1) | |
| | missing | 6 (1) | 2 (1) | |

Abbreviations: ABC, abacavir; AZT, zidovudine; 4DT, stavudine; EFV, efavirenz; IQR, interquartile range; NVP, nevirapine; TB, tuberculosis; 3TC, lamivudine; WHO, World Health Organization.
[a]Pearson $\chi^2$ test.
[b]Kruskal-Wallis test.

failure was 379 days (IQR 229–649). Immunological failure alone occurred in 100 (46%) children, while clinical failure alone was found in 116/218 (53%) cases. Two children (1%) had concomitant clinical and immunological failure. Baseline characteristics are shown in Table 2.

The adjusted Cox proportional hazards model of treatment failure with the lowest AIC included age, treatment type, and baseline disease stage. Incidence rates and crude and adjusted relative hazards from the model are shown in Table 3.

Patients with TB and those with other WHO stage 4 defining diseases were significantly more likely to experience treatment failure (Hazard Ratio [HR] 2.27, 95% CI 1.5–3.4, $P < 0.01$ and HR 1.57, 95% CI 1.02–2.4, $P = 0.04$, respectively) compared to children with WHO stage 3 disease without TB. As expected, starting cART with an unconventional regimen (not containing an NRTI backbone in combination with EFV, NVP, lopinavir/ritonavir (LPV/r), or ABC) was also significantly associated with risk of treatment failure (HR 3,37, 95% CI 1.12–11.89, $P = 0.03$).

**Drug Substitution Analysis.** Among 862 eligible children, 4 with unknown ART regimen and 89 who received ABC in their initial cART regimen were excluded from the cART drug-substitution analysis. The remaining 769 children had an overall follow-up of 1499 person/years. Baseline characteristics of this cohort are provided in Supplementary Table 1 (see online Supplementary Material for this table).

Throughout the study period, 202 (26%, 95% CI 23–30) patients substituted treatment, with median time to substitution of 9.69 months (IQR 25.82). Overall incidence of substitution was 15.4 events per 100 person-years (95% CI 13.4–17.7). Reported reasons for substitution included any toxicity (37, 18.3%), of which 3 were d4 T toxicity (1.5%), 25 (12.4%) AZT toxicity, and 9 (4.5%) NVP toxicity, clinical and immunological failure (9, 4.5%), drug availability (35, 17.3%), drug interaction (1, 0.5%), provider preference for a better option (32, 15.8%), simplification associated with nonadherence (4, 2%), caregiver health problem (1, 0.5%), and TB drugs interaction (52, 25.7%). Among the 9 patients with drug substitution for clinical or immunological failure, median time to

**Table 2.** Baseline Characteristics of Children Included in the Treatment Failure Analysis: Demographics and Treatment

| Variable | Value | All children n = 740 (100.00%) | Mozambique n = 492 (66.49%) | Uganda n = 248 (33.51%) | *P* value[3] |
|---|---|---|---|---|---|
| Gender | Male | 382 (51.62) | 260 (52.85) | 122 (49.19) | 0.348 |
| | Female | 358 (48.38) | 232 (47.15) | 126 (50.81) | |
| Age at treatment initiation (n = 205) | Median (IQR) | 5.05 (7.00) | 3.42 (5.49) | 8.22 (7.13) | <0.01 |
| | <12 months | 51 (6.89) | 44 (8.94) | 7 (2.82) | <0.01 |
| | 12-35 months | 216 (29.19) | 186 (37.80) | 30 (12.10) | |
| | 36-59 months | 97 (13.11) | 68 (13.82) | 29 (11.69) | |
| | >5 years | 376 (50.81) | 194 (39.43) | 182 (73.39) | |
| BMI for age z-score | Median (IQR) | −0.92 (1.94) (n = 564) | −1.10 (1.95) (n = 327) | −0.75 (1.82) (n = 237) | 0.019 |
| WHO disease stage | Stage I or II | 174 (23.51) | 46 (9.35) | 128 (51.61) | <0.01 |
| | Stage III with TB | 83 (11.22) | 68 (13.82) | 15 (6.05) | |
| | Stage III w/o TB | 305 (41.22) | 224 (45.53) | 81 (32.66) | |
| | Stage IV with TB | 52 (7.03) | 48 (9.76) | 4 (1.61) | |
| | Stage IV w/o TB | 101 (13.65) | 81 (16.46) | 20 (8.06) | |
| | Unknown | 25 (3.38) | 25 (5.08) | 0 (0.00) | |
| Initial treatment regimen | 3TC + d4T + NVP | 325 (43.92) | 269 (54.67) | 56 (22.58) | <0.01 |
| | 3TC + AZT + NVP | 195 (26.35) | 114 (23.17) | 81 (32.66) | |
| | 3TC + AZT + EFV | 69 (9.32) | 13 (2.64) | 56 (22.58) | |
| | 3TC + d4T + EFV | 50 (6.76) | 24 (4.88) | 26 (10.48) | |
| | 3TC + AZT + LPV/r | 18 (2.43) | 0 (0.00) | 18 (7.26) | |
| | 3TC + d4T + LPV/r | 6 (0.81) | 0 (0.00) | 6 (2.42) | |
| | 3TC + d4T + ABC | 25 (3.38) | 25 (5.08) | 0 (0.00) | |
| | 3TC + AZT + ABC | 40 (5.41) | 39 (7.93) | 1 (0.40) | |
| | Other[b] | 12 (1.62) | 8 (1.63) | 4 (1.61) | |
| Initial treatment regimen (by most potent component) | EFV-containing | 120 (16.22) | 37 (7.52) | 83 (33.47) | <0.01 |
| | NVP-containing | 523 (70.68) | 383 (77.85) | 140 (56.45) | |
| | LPV/r-containing | 24 (3.24) | 0 (0.00) | 24 (9.68) | |
| | ABC-containing[c] | 67 (9.05) | 66 (13.41) | 1 (0.40) | |
| | Other[d] | 6 (0.81) | 6 (1.22) | 0 (0.00) | |
| Adherence | Good | 485 (65.54) | 294 (59.76) | 191 (77.02) | <0.01 |
| | Poor | 255 (34.46) | 198 (40.24) | 57 (22.98) | |
| CD4 percent (mean, 95% CI) | <12 months | 15.95 (9.60) | 15.60 (9.20) | 18.93 (4.60) | <0.01 |
| | 12-35 months | 14.50 (8.70) | 15.00 (8.20) | 10.62 (8.12) | |
| | 36-59 months | 12.16 (7.90) | 12.85 (7.05) | 11.81 (8.77) | |
| | >5 years | 9.60 (10.00) | 11.05 (10.00) | 8.47 (9.76) | |
| CD4 count (mean cells/mm$^3$, 95% CI) | <12 months | 784.00 (971.00) | 746.50 (765.50) | 1404.00 (1145.00) | <0.01 |
| | 12-35 months | 721.00 (606.00) | 730.50 (585.00) | 554.00 (765.00) | |
| | 36-59 months | 467.00 (395.50) | 420.50 (292.50) | 551.00 (509.00) | |
| | >5 years | 239.00 (286.00) | 265.00 (363.00) | 226.00 (224.00) | |
| CD4 count z-score | Median (IQR) | −0.30 (1.07) (n = 736) | −0.14 (1.12) (n = 492) | −0.54 (0.69) (n = 244) | <0.01 |
| Classification of immunodeficiency[e] | Not significant | 58 (7.84) | 40 (8.13) | 18 (7.26) | 0.092 |
| | Mild | 35 (4.73) | 19 (3.86) | 16 (6.45) | |
| | Advanced | 66 (8.92) | 37 (7.52) | 29 (11.69) | |
| | Severe | 581 (78.51) | 396 (80.49) | 185 (74.60) | |

Abbreviations: ABC, abacavir; AZT, zidovudine; BMI, body–mass index; CI, confidence interval; d4 T; EFV; IQR, interquartile range; LPV/r; NVP, nevirapine; TB, tuberculosis; 3TC, lamivudine; WHO, World Health Organization.

[a]*P* values refer to differences between Mozambique and Uganda subcohorts on baseline characteristics.

[b]Other regimens include mono or dual therapies and those with missing information on combination antiretroviral therapy regimen.

[c]ABC-containing regimen includes a 3 NRTI regimen containing ABC.

[d]Other regimens include only those without an EFV, NVP, LPV/r, or ABC component, regardless of number of components.

[e]Immunodeficiency was classified as mild (CD4% of 30–35, 25–30, 20–25 and CD4 cell count of 350–499 for children ≤11 months, 12–35 months, 36–59 months or ≥5 years, respectively), advanced (CD4% of 25–29, 20–24, 15–19 and CD4 cell count of 200–349 for children ≤11 months, 12–35 months, 36–59 months or ≥5 years, respectively) and severe (CD4% <25, <20, <15 and CD4 cell count <200/<15% for children ≤11 months, 12–35 months, 36–59 months or ≥5 years, respectively) according to the WHO 2006 thresholds.

substitution was 26.65 months (IQR 23.95). Reasons for substitution were unknown for 31 (15.3%) children.

Drug substitution was more likely among patients starting 3TC-AZT-NVP (adjusted HR 3.29, 95% CI 2.27–4.76, $P < 0.01$), 3TC-d4T-EFV (adjusted HR 3.22, 95% CI 2.02-5.13, $P < 0.01$), or 3TC + AZT + EFV (adjusted HR 1.74, 95% CI 1.03–2.95, $P = 0.037$) compared to 3TC-d4T-NVP.

Mildly immunosuppressed patients (adjusted HR 2.23, 95% CI 1.24–4.02, $P < 0.01$), infants (adjusted HR 2.74, 95% CI 1.54–4.90, $P < 0.01$), children with TB (adjusted HR 3.38, 95% CI 2.28–5.01, $P < 0.01$) and those with good treatment adherence before drug substitution (adjusted HR 0.53, 95% CI 0.37–0.77, $P < 0.01$) were also more likely to substitute cART. Incidence rates and crude and adjusted

**Table 3.** Relative Hazards for Treatment Failure in Children From Mozambique and Uganda ($n = 740$ Children)

| Variable | | Person time (years) | Events | Crude incidence rate[a] (95% CI) | Unadjusted relative hazard | 95% CI | *P* value | Adjusted relative hazard | 95% CI | *P* value |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatment type | NVP-containing | 781.2 | 150 | 19.2 (16.4,22.5) | Reference | | | Reference | | |
| | ABC-containing[b] | 62.0 | 18 | 29.0 (18.3,46.1) | 1.38 | (0.84,2.25) | 0.20 | 0.76 | (0.43,1.34) | 0.34 |
| | EFV-containing | 187.5 | 37 | 19.7 (14.3,27.2) | 1.09 | (0.76,1.56) | 0.65 | 0.95 | (0.64,1.41) | 0.80 |
| | LPV/r-containing | 53.8 | 10 | 18.6 (10.0,34.5) | 1.08 | (0.56,2.08) | 0.81 | 1.03 | (0.53,2.02) | 0.93 |
| | Other[c] | 3.9 | 3 | 76.1 (24.6,236.1) | 3.32 | (1.05,10.43) | 0.04 | 3.73 | (1.17,11.89) | 0.03 |
| BMI for age z-score tertiles | Lowest tertile | 410.7 | 96 | 23.4 (19.1,28.6) | Reference | | | | | |
| | Middle tertile | 260.6 | 42 | 16.1 (11.9,21.8) | 0.69 | (0.48,0.99) | 0.04 | | | |
| | Highest tertile | 154.1 | 38 | 24. 7 (17.9,33.9) | 1.04 | (0.71,1.51) | 0.85 | | | |
| | Unknown | 263.1 | 42 | 16.0 (11.8,21.6) | 0.68 | (0.48,0.98) | 0.04 | | | |
| Gender | Female | 540.7 | 100 | 18.5 (15.2,22.5) | Reference | | | | | |
| | Male | 547.8 | 118 | 21.5 (18.0,25.8) | 1.17 | (0.89,1.52) | 0.26 | | | |
| Country of treatment | Mozambique | 681.5 | 143 | 21.0 (17.8,24.7) | Reference | | | | | |
| | Uganda | 407.0 | 75 | 18.4 (14.7,23.1) | 0.91 | (0.69,1.21) | 0.51 | | | |
| Adherence | Good | 1027.3 | 202 | 19.7 (17.1, 22.6) | Reference | | | | | |
| | Poor | 61.1 | 16 | 26.2 (16.0, 42.7) | 1.24 | (0.74,2.06) | 0.41 | | | |
| Classification of immunodeficiency[d] | Not significant | 78.6 | 10 | 12.7 (6.8,23.6) | 0.58 | (0.31,1.10) | 0.10 | | | |
| | Mild | 57.9 | 11 | 19.0 (10.5,34.3) | 0.89 | (0.49,1.64) | 0.72 | | | |
| | Advanced | 90.3 | 13 | 14.4 (8.4,24.8) | 0.64 | (0.36,1.12) | 0.12 | | | |
| | Severe | 861.7 | 184 | 21.4 (18.5,24. 7) | Reference | | | | | |
| Age group | 0–11 months | 46.0 | 13 | 28.2 (16.4,48.6) | 1.28 | (0.72,2.23) | 0.41 | 1.08 | (0.59,1.96) | 0.80 |
| | 12–35 months | 275.5 | 64 | 23.2 (18.2,29.7) | 1.12 | (0.83,1.52) | 0.46 | 1.08 | (0.77,1.50) | 0.66 |
| | 35–59 months | 176.8 | 23 | 13.0 (8.6,19.6) | 0.67 | (0.43,1.05) | 0.08 | 0.64 | (0.41,1.00) | 0.05 |
| | ≥5 years | 590. 1 | 118 | 20.0 (16.7,24.0) | Reference | | | Reference | | |
| WHO disease stage at baseline | Stage 1 or 2 | 289.0 | 52 | 18.0 (13.7,23.6) | 1.12 | (0.79,1.58) | 0.52 | 1.17 | (0.81,1.67) | 0.40 |
| | Stage 3 or 4 with TB | 145.8 | 50 | 34.3 (26.0,45.2) | 1.96 | (1.38,2.79) | <0.01 | 2.27 | (1.50,3.42) | <0.01 |
| | Stage 3 w/o TB | 510.9 | 83 | 16.2 (13.1,20.1) | Reference | (0.78,7.7) | 0.045 | Reference | | |
| | Stage 4 w/o TB | 106.3 | 29 | 27.3 (19.0,39.3) | 1.54 | (1.01,2.35) | 0.40 | 1.57 | (1.02,2.414) | 0.04 |
| | Unknown | 36.5 | 4 | 11.0 (4.1,29.2) | 0.65 | (0.24,1.78) | | 0.67 | (0.24,1.82) | 0.43 |

Abbreviations: ABC, abacavir; BMI, body–mass index; CI, confidence interval; EFV, efavirenz; LPV/r, lopinavir/ritonavir; NVP, nevirapine; WHO, World Health Organization.

[a]Per 100 years.

[b]ABC-containing regimen include a 3 NRTI regimen containing ABC.

[c]Other regimens include only those without an EFV, NVP, LPV/r, or ABC component, regardless of number of components.

[d]Immunodeficiency was classified as mild (CD4% of 30–35, 25–30, 20–25 and CD4 cell count of 350–499 for children ≤11 months, 12–35 months, 36–59 months or ≥5 years, respectively), advanced (CD4% of 25–29, 20–24, 15–19 and CD4 cell count of 200–349 for children ≤11 months, 12–35 months, 36–59 months, or ≥5 years, respectively) and severe (CD4% <25, <20, <15 and CD4 cell count <200/<15% for children ≤11 months, 12–35 months, 36–59 months or ≥5 years, respectively) according to the WHO 2006 thresholds.

relative hazards from the model are shown in Supplementary Table 2 (see online Supplementary Material for this table).

## DISCUSSION

In this study, a notable proportion (29%) of HIV-positive children experienced clinical and/or immunological cART failure, with a crude incidence rate of 20.0 events per 100 person-years. Our findings appear to be in line with evidence from the literature referring to immunological failure [16–18]. Considering that virological failure tends to precede clinical and immunological failure, this figure could underestimate a greater impact of virological failure.

WHO clinical stage 4 and TB co-infection at cART initiation were significantly associated with treatment failure. Poor clinical status has been observed to negatively affect treatment response; in particular, malnutrition and chronic diarrhea independently increase the risk of treatment failure as much as baseline low immunity, high viral load (VL), and younger age [15–17]. As suggested by Hermans et al. [40, 41], TB co-infection may impair immune recovery after cART initiation in adults. In addition, poor adherence may occur as a result of high pill burden, and interaction with rifampicin may affect the bioavailability of HIV drugs, particularly for NVP and LPV/r [42]. Development of better options for TB co-treatment appears to be critical to prolong effectiveness of first-line regimens.

As expected, unconventional regimens were associated with treatment failure compared to triple cART [37]. Treatment failure was not different between PI-based and NNRTI-based regimens; however, the validity of this finding may be questionable considering that only a few children were receiving a PI-based regimen at the time of the study. Few randomized trials investigated the most effective first-line cART regimen in HIV-positive children. The P1060 trial [13, 23] showed an increased risk of virological failure in children (<3 years) on NPV-based cART, regardless of prevention of mother to child transmission (PMTCT) exposure; however, this was not confirmed by the PENPACT trial conducted in older children of high-income countries [24]. Due to the nature of our cohort's age and lack of reliable PMTCT exposure data, our observational retrospective findings are not comparable to those from either controlled trial.

Reasons for drug substitution were assessed to explore whether this was in response to treatment failure. However, over a 5-year period, only 4% of 202 patients who substituted cART switched to a second-line regimen due to treatment failure. Drug substitution occurred after a median time of 26.65 months, indicating a significant delay in switching to second-line despite the high rate of failure retrospectively observed in the cohort. Although reasons for substitution may have been misclassified, the small number of children switching due to treatment failure implies that a prolonged exposure to failing regimens may have occurred in these two settings. Several studies reported a low proportion of children on second-line cART in LMIC [19, 20]. Our switch rate appears even lower than those observed by Davies et al. [16] and by 2 other observational studies showing that around 14% children switched to second-line due to clinical and/or immunological failure [17, 18]. Reasons explaining the alarming gap between a recognized clinical and/or immunological failure and the initiation of a second-line cART were not well identified. In our program, we hypothesize that limited availability and costs of second-line drugs may be major barriers to second-line therapy. Furthermore, the tradeoff that clinicians are facing when considering the limited options for children failing first-line and the risk of maintaining them on a failing regimen can be very challenging and may result in further delays in switching to second-line cART. Underdiagnosis of treatment failure may also have contributed to the low rate of switching observed, as reasons for switching were collected retrospectively based on clinician report, leading to possible misclassification.

Determining when to switch to second-line cART is a critical decision in settings where virological monitoring is not available. Although evidence shows that VL is not essential to identify treatment failure [34], using clinical and immunological parameters leads to delays in switching to second-line therapy [17], resulting in longer exposure to failing regimens, which contributes to development of drug-resistant HIV strains [6]. In our study, reasons for delays to cART switching were not completely clarified; in particular, we were unable to understand if clinicians did not switch cART in children with recognized treatment failure or if clinical/immunological criteria were too complicated to recognize treatment failure. Earlier cART initiation and VL monitoring are currently recommended by WHO 2013 consolidated guidelines [3]. Based on our data, advanced disease and TB co-infection should be considered as warning signals requiring closer follow-up and counseling to improve treatment outcomes and prolong duration of first line therapy. Adherence to cART was found to be a poor indicator of treatment failure, maybe due to the low accuracy of self-reporting adherence monitoring.

About 26% (203/769) of patients substituted treatment with an overall incidence rate of 13.5 events per 100 person years and 95% of these were for causes other than treatment failure. This figure is consistent with previous

observational studies among HIV-positive children [17,24, 40] living in LMIC. Toxicity/intolerance was one of the main reasons reported for substitution (18.3%), mostly related to AZT toxicity (12.4%), as reported in other studies [17,38,41]. Due to high prevalence of HIV/TB co-infection (88/769, 11.4%), drug interaction in TB/HIV co-treatment (25.7%) was another major reason to substitute drugs. Drug availability (17.3%) was another considerable reason, reflecting the importance of ensuring adequate and continuous supply of cART in settings where drug costs are still a major barrier for PLWH. Reasons for drug substitution were not classified prospectively but assessed from inspection of patient clinical charts, potentially leading to inaccurate classifications.

Higher rates of drug substitution were observed among children starting AZT-containing or EFV-based regimens. Increased drug substitution while on AZT is often the result of AZT-related anemia as well described previously [23, 31, 36]. AZT toxicity was more prevalent among the Mozambique cohort, where children were younger and malnutrition and/or more advanced WHO disease stages were observed, suggesting that AZT anemia may have been exacerbated. Despite the lack of more robust evidence, our findings suggest that AZT may not be the preferred NRTI to be used in these settings, particularly in younger children.

Further description of EFV substitution was not possible in this dataset due to the limited number of children receiving this drug, and we could not rule out specific EFV-related toxicity.

As previously mentioned, our results may be confounded by country-specific differences. Mozambique patients were younger, had a more advanced WHO stage, and a lower BMI z-score at cART initiation. These differences may reflect clinicians' preference in first-line treatment choice, accounting for the wider use of AZT and EFV in Uganda as much as for the increased choice of NVP-based regimen observed in children from Mozambique. Country-specific differences may potentially confound the relationships seen between cART regimen and treatment failure and drug substitution. In terms of follow-up visits, the Ugandan children were followed up much more frequently (monthly) than those in Mozambique (every 3 months). This difference between program performances may have provided further confounders, potentially influencing the trends observed in older children at lower risk of failure and the higher rate of drug substitution observed in infants.

In conclusion, our data reinforce the need for simplification of more effective clinical and immunological criteria for prompt recognition of cART treatment failure. Children presenting with advanced disease and TB co-infection should be targeted for closer and more sensitive monitoring of treatment response. This should be matched with a regular provision of appropriate antiretrovirals and with optimization of first-line drugs and treatment sequencing. Supply of new pediatric formulations for second-line regimens and drug optimization should be considered as critical milestones to allow scaling up of early cART and reduction of treatment failure in children.

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All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

## Supplementary Data

Supplementary materials are available at the *Journal of The Pediatric Infectious Diseases Society* online (http://jpids.oxfordjournals.org). Supplementary materials consist of data provided by the author that are published to benefit the reader. The posted materials are not copyedited. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

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# Harmonization of clinical laboratories in Africa: a multidisciplinary approach to identifying innovative and sustainable technical solutions

Laboratory medicine plays a fundamental role in ensuring the efficiency and effectiveness of health care systems and making possible timely diagnoses and operations. However, in the Sub-Saharan African region it is frequently of poor quality, due in part to insufficient economic resources, in part to a lack of personnel trained in using technical diagnostic tools, and in part to the difficulties of transporting and supplying materials.

This study analyzed four hospitals in three countries where Doctors with Africa is active with health care projects – Uganda (Aber), South Sudan (Lui and Yrol) and Sierra Leone (Pujehun) – in order to evaluate the diagnostic laboratory services available in the health centers there and compare them with the standard values.

Its findings highlight the urgent need to intervene in this oft-neglected area of health care, making basic changes to prevent the waste of resources (sterilizing and using tools appropriately, guaranteeing the transport of and cataloguing available materials and tools) even before attempting to modify protocols and procedures, thus making it possible for laboratory medicine to evolve in a sustainable manner in lower-income countries as well.

Open Access

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# Harmonization of clinical laboratories in Africa: a multidisciplinary approach to identify innovative and sustainable technical solutions

**Abstract**

**Background:** In an effective and efficient health system, laboratory medicine should play a critical role. This is not the case in Africa, where there is a lack of demand for diagnostic exams due to mistrust of health laboratory performance. Doctors with Africa CUAMM (Collegio Universitario Aspiranti Medici Missionari) is a non-profit organization, working mainly in sub-Saharan Africa (Angola, Ethiopia, Mozambique, Sierra Leone, South Sudan, Tanzania and Uganda) to help and sustain local health systems. Doctors with Africa CUAMM has advocated the need for a harmonized model for health laboratories to assess and evaluate the performance of the facilities in which they operate.

**Methods:** In order to develop a harmonized model for African health laboratories, previous attempts at strengthening them through standardization were taken into consideration and reviewed. A survey with four Italian clinicians experienced in the field was then performed to try and understand the actual needs of health facilities. Finally a market survey was conducted to find new technologies able to update the resulting model.

**Results:** Comparison of actual laboratories with the developed standard – which represents the best setting any African health laboratory could aim for – allowed shortcomings in expected services to be identified and interventions subsequently prioritized. The most appropriate equipment was proposed to perform the envisaged techniques. The suitability of appliances was evaluated in consideration of recognized international recommendations, reported experiences in the field, and the availability of innovative solutions that can be performed on site in rural areas, but require minimal sample preparation and little technical expertise.

**Conclusions**: The present work has developed a new, up-to-date, harmonized model for African health laboratories. The authors suggest lists of procedures to challenge the major African health problems – HIV/AIDS, malaria, tubercolosis (TB) – at each level of pyramidal health system. This model will hopefully support the non-governmental organization (NGO) Doctors with Africa CUAMM in its activities in sub-Saharan hospitals, providing them with a guideline to programme future interventions.

**Keywords:** Africa; clinical laboratory; harmonization; technology; sustainability.

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## Introduction

The majority of African health systems have been inherited from colonial governments and were focused primarily on the healthcare of colonial administrators and expatriates [1]. Local health systems have also been adversely affected by lack of investments, resulting in a general weakening of health infrastructures. Unfortunately foreign aid is unable to solve the issue of the lack of resources, which remain scarce. There are shortages of drugs or medical equipment and human resources are often insufficient in number [2, 3]. Moreover, staff is not always well-trained: the majority of African health workers have mid-level qualifications and only 9.7% have a degree as a medical doctor [2]. The phenomena generally described for health systems affect clinical laboratories

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too. Laboratory medicine should play a critical role in effective and efficient management of healthcare, but this is not the case in Africa [4]. Laboratory expenditure is frequently prohibitive for African health systems, which are adversely affected by corruption. For instance, 95% of financial resources allocated for Ghanaian healthcare are allocated to the individual [5] and thus procurement of medical devices is not guaranteed [6].

According to experience in the field, procedures are not always carried out accurately due to the inadequacy of infrastructures – such as power and water supply networks.

The crucial role of health laboratories in diagnosing and treating pathologies has also recently been recognized within the African framework, as demonstrated by World Health Organization (WHO) Resolution number AFR/RC58/R2 [7] and the Maputo consultation [8]. Several efforts have accordingly been made to fill the gaps in laboratory medicine. For instance, some governments and associations, such as the African Society for Laboratory Medicine (ASLM), are working on strengthening the laboratory workforce – by training and certifying laboratory professionals through standardized frameworks – and on enrolling laboratories in quality improvement programmes to achieve accreditation by international standards [9].

Recently several authors have demonstrated that harmonization [10] of laboratory activities is a critical step in developing health systems. Specifically, it allows more accurate understanding and planning of facility needs, which in turn would avoid, for example, the expiry of medicines and consumables and the consequent wastage of resources. The aim of this work was to follow this initiative and to sustain the activity of Doctors with Africa-CUAMM, an Italian NGO whose mission is to develop sub-Saharan health services. CUAMM needed a ground plan to manage the health laboratories they would help, by structuring their activities, procedures and resources and prioritizing investments. To fulfil this requirement, a new, up-to-date, harmonized model for African health laboratories has been developed. To address the major health problems, this work proposes lists of procedures for each level of the pyramidal network of health laboratories. An evaluation was made to select and suggests the most appropriate equipment. The suitability of appliances was assessed in accordance with recognized international recommendations, reported experiences in the field, and the availability of innovative solutions that can be implemented on site in rural areas, while requiring minimal sample preparation and little technical expertise. The effectiveness of the developed standard was tested by evaluating the performance of four different healthcare facilities managed by CUAMM and by submitting it to clinicians with experience in the field. Comparison between actual and theoretical conditions allowed gaps to be identified in the service offered and to programme future interventions, taking into account the major health problems of local communities.

## Materials and methods

The reported analysis began with the assessment of previous attempts at harmonization of laboratory medicine [8, 11–14]. The WHO archive was the major source of data and one of its documents represents the cornerstone of the proposed standard [13]. It was established that each new publication about laboratory medicine must consider all the most recent discoveries in the field and each innovative procedure or technology. More recent publications on health laboratory services have also been taken into account: the most relevant concerns the work of the Maputo Conference (22–24 July 2008) [8], where international attention focused on the diagnostic tests required at each level of the tiered health laboratory network.

However, since the aim of the present work was to support CUAMM's interventions in sub-Saharan Africa, a survey was performed to understand the actual needs of the local health workforce, with the help of four clinicians experienced in the field, working with Doctors with Africa. Attention was specifically directed at four case studies, which were compared with the developed standard to assess performance. All the evaluated health facilities serve district hospitals, in Aber (Uganda), Lui, Yirol (South Sudan) and Pujehun (Sierra Leone), respectively (Figure 1). CUAMM's reports provided data on the effective workload of the four case studies and also on the current workforce. Finally, a market survey was conducted to include the most recent scientific and technological innovations that allow CUAMM to perform all envisaged laboratory procedures, avoiding wastage of resources and taking advantage of available, but relatively unqualified staff.

A review of previous works on laboratory harmonization showed that the health laboratory system could only be strengthened through harmonization of laboratory activities and equipment [3, 10]. In the present model, laboratory procedures have been proposed for four theoretical levels of the tiered health laboratory network, in accordance with the Maputo Meeting Report [8]. The lowest level is defined as the primary laboratory level and consists of all laboratory units serving health centres and rural hospitals. This level also includes mobile units and microscopy centers.

Above the first level are the district laboratories connected to hospitals of the same name. The third level of the network is represented by provincial or regional facilities while the national laboratories stand at the top of the network. The present work did not establish or propose a standard model for the uppermost level of the network because facilities at this level are strictly governed at the national level, with their own national programmes, guidelines and ad hoc standards – or are connected with academic institutions interested in specific research fields.

The first step was to propose a list of health problems that each of the above-reported levels must be able to treat. Primary health laboratories should manage HIV/AIDS, malaria, tuberculosis (TB) [15], syphilis, various infections, noncommunicable diseases, endemic


**Figure 1:** A photographic overview of evaluated district laboratories.

diseases such as human African trypanosomiasis, and pregnancy. It is also deemed necessary for primary facilities to implement diagnostic techniques for clinical chemistry and hematology.

According to the present standard, district laboratories should treat the same pathological and physiological conditions managed at the primary level in addition to handling hepatitis B and C and inpatient monitoring.

Provincial laboratories have to manage all the previous states in the same way as Western facilities.

## Results and discussion

A brief summary of the activities envisaged for primary and district health laboratories in Africa is reported in Table 1. It has been suggested to implement rapid diagnostic tests (RDTs) because they are generally less expensive than traditional methods, and are readily usable and understandable, even by less qualified personnel. RDTs would mainly be used not only for diagnosing and/or screening main diseases (such as HIV/AIDS, malaria or syphilis) but also for less common ones, as human African trypanosomiasis (Figure 2).

A new method to detect tuberculosis and drug resistance has been implemented by Xpert® MTB/RIF. It has been demonstrated that the MTB/RIF test is less dependent on user skills, and can be utilized by staff with minimal training. Turnaround time is also short since the test simultaneously detects tuberculosis and rifampin

**Table 1:** Standardized panel of activities for primary and district African health laboratories.

| Pathologies/conditions | Suggested procedures | |
|---|---|---|
| | Primary labs | District labs |
| HIV/AIDS | RDTs | RDTs and EIA; CD4 counts; cryptococcal antigen |
| Malaria | RDTs; microscopy (thick and thin film) | RDTs; microscopy (thick and thin film) |
| Tuberculosis | Microscopy (Ziehl-Neelsen) | Microscopy (Ziehl-Neelsen); Xpert® MTB/RIF |
| Syphilis | RDTs | RPR (I); TPPA/TPHA (II) |
| Clinical chemistry | Dry chemistry analyser or traditional techniques [glucose; ALT(III); creatinine] | Wet chemistry analyzer (complete chemistry panel) |
| Hepatitis B and C | Not envisaged | HbsAg(IV) and HCV(V); EIA |
| Hematology | Hemoglobinometer or Drabkin's solution method [HGB (VI)] | Haemoglobinometer or Hct (VII) estimation (HGB); blood cell counts; type and crossmatch |
| Other | Not envisaged | CSF(VIII) chemistry and cell counts; procedures for endemic diseases [CATT(IX), Widal test, etc.] |

(I) RPR, Rapid plasma reagin; (II) TPPA/TPHA, Treponema Pallidum Hemoagglutination Assay/Treponema Pallidum Particle Assay; (III) ALT, alanine transaminase; (IV) HbsAg, hepatitis B surface antigen; (V) HCV, hepatitis C virus; (VI) HGB, hemoglobin; (VII) Hct, hematocrit; (VIII) CSF, cerebrospinal fluid; (IX) CATT, Card Agglutination Test for Trypanosomiasis.

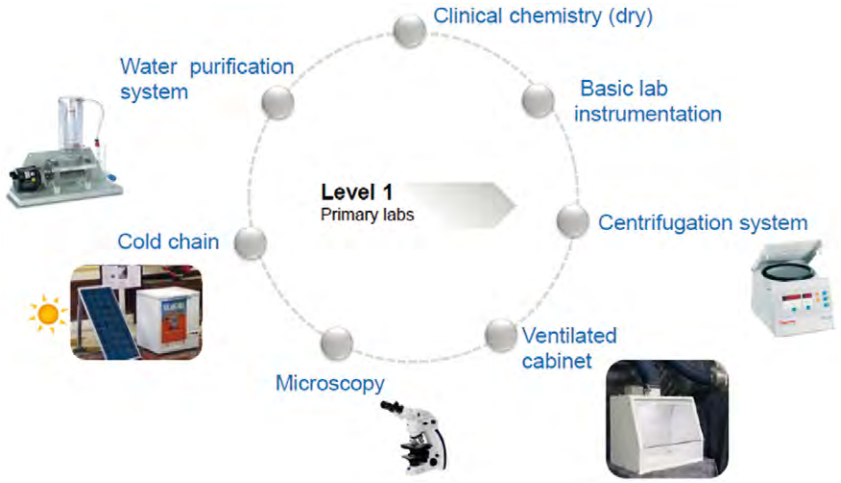


**Figure 2:** Standard instrumental equipment proposed for primary laboratories.

resistance in <3 h [16]. Moreover, Xpert® MTB/RIF permits TB to be diagnosed with the advantages of dry chemistry: i.e., reagents can be stored at room temperature; no large amounts of water are required; there is no need for additional plumbing; basic servicing activities suffice; and no staff with specific skills are needed. This equipment is also recommended in part because of its price: following WHO negotiation, laboratories in endemic countries can procure it at a fair rate [17].

Table 1 clarifies a few points. Analysis of thin film samples for malaria diagnosis in primary laboratories can only be performed if adequate safety devices are available for workers. The same applies to samples of cerebrospinal fluid (CSF), which can only be tested if a lumbar puncture is performed and personnel able to perform one are available.

The present model takes into account that some facilities are seriously underdeveloped. Accordingly, dry clinical chemistry techniques can also be considered acceptable in district laboratories, although wet chemistry remains the best solution (Figure 3). As noted in Table 1, the introduction of enzyme immunoassay (EIA) techniques in district laboratories is pivotal because the same instrumentation can be used to carefully diagnose both HIV/AIDS and hepatitis (although different kits are obviously needed).

Provincial laboratories can perform the same panel of activities as district ones, in addition to carrying out nucleic acid tests for HIV/AIDS; acid-fast bacilli (AFB) smears, culture, identification and susceptibility for tuberculosis; cell cultures and polymerase chain reaction (PCR) techniques as supplementary tests.

Concerning standardized technologies and equipment, the present model suggests that primary laboratories must have at least a scale for weighing products and reagents; a hot plate or equivalent; a mixer; a Bunsen burner; a pH meter; a bench centrifuge; a microscope; a colorimeter; a hemoglobinometer; a glucometer or dry chemistry analyser; a laboratory refrigerator; a water purification system; and a ventilated workstation. The latest technology was introduced to protect health workers from the use of dangerous substances, such as ethanol or HCl, and particularly during the Ziehl-Neelsen procedure, which requires adequate aeration. A feasible option is the model developed by the Global Laboratory Initiative [18] which provides instructions on how to produce a cheap, effective ventilated workstation with the option of mounting a HEPA (high efficiency particulate air) filter.

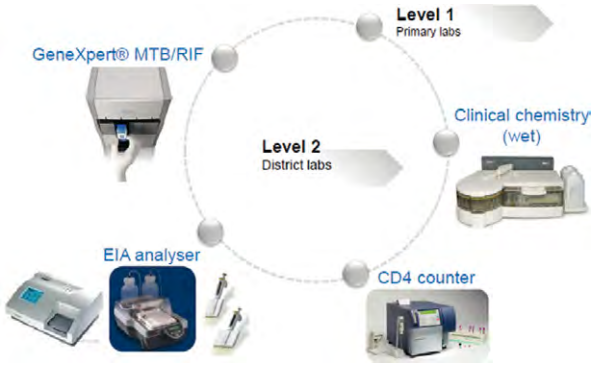


**Figure 3:** Standard instrumental equipment proposed for district laboratories.

The SolarChill battery-free unit represents an interesting alternative to traditional refrigerators [19]. Only devices for vaccines have been developed to date, but they can also be appropriately used for the present standard, while waiting for a specific one.

Relevant initiatives have also been taken for traditional instruments as the microscope. The Foundation for Innovative New Diagnostics (FIND) has effectively negotiated with Carl Zeiss over the price of a special microscope, the PrimoStar iLED [20], which works both as a simple microscope but also in fluorescence – essential for special techniques that have recently been recommended by WHO to diagnose TB.

District laboratories must have the same equipment as primary ones; in addition they should have cell counters; CD4 counters, in accordance with Westerman et al. [21]; EIA analyzers; a wet chemistry analyzer; a laboratory freezer; and Xpert® MTB/RIF. Lastly, provincial laboratories should also have a $CO_2$ incubator and biosafety cabinet for cell cultures.

A comparison was then made between the developed standardized model and the four case studies managed by Doctors with Africa CUAMM. The facilities at Aber, Lui, Pujehun and Yirol are all district laboratories. First, panels of laboratory activities were compared with the standard; the results are shown in Table 2. Comparing the standardized model with actual performance in selected case studies permitted gaps to be identified in the expected health service. In particular it was observed that it is frequently difficult to perform thin film analysis for malaria diagnosis. This prevents the *Plasmodium* causing the disease from being clearly identified, so treatments are often not focused. Similarly EIA techniques, CD4 counts and cryptococcal antigen tests are not performed; Xpert® MTB/RIF has not yet been introduced into African laboratories, despite WHO recommendations. Another relevant question concerns clinical chemistry, which is fundamental in addressing the expected increase in non-communicable diseases in the African region over the coming years.

Comparison of the inventory of theoretically and actually available technology has highlighted several shortages, strictly connected to the items missing from the panel of procedures. As shown in Table 3, there is an insufficient number of ventilated cabinets, clinical chemistry analyzers and no EIA analyzer or Xpert® MTB/RIF have yet been purchased. Using the standardized model as a guideline has also highlighted the scarcity of data about basic laboratory instrumentation, as mixers, thermostatic baths, weighing scales and other similar devices. This should prompt recommendation of a more accurate collection of information on these technologies in order to establish a solid investment plan. If the lack of basic instrumentation is confirmed, priority must be given to

**Table 2:** Number of case studies complying with requirements of standard for district laboratory activities.

| Procedure | No. of case studies completely complying with requirements of standard |
|---|---|
| RDTs for HIV/AIDS | 4 |
| EIA for HIV/AIDS | 0 |
| Microscopy for malaria | 0 |
| AFB(I) for TB | 4 |
| Xpert® MTB/RIF | 0 |
| RPR, TPPA/TPHA for syphilis | 1 |
| Pregnancy test | 4 |
| Hemoglobinometry | 2 |
| Clinical chemistry | 1 |
| Type and cross match | 3 |
| ESR(II) | 3 |
| HCV and HbsAg | 3 |
| Cell count | 1 |
| CD4 count | 1 |
| Cryptococcal antigen test | 0 |
| CSF microscopy | 2 |
| Microscopy | 3 |
| Tests for endemic diseases | 4 |

(I)AFB, Acid fast bacilli; (II)ESR, erythrocyte sedimentation rate.

**Table 3:** Number of case studies complying with requirements of standard for district laboratory equipment.

| Equipment | No. of case studies completely complying with requirements of standard |
|---|---|
| Mixer | Data not available |
| Clinical chemistry analyzer | 1 |
| Thermostatic bath | 1 |
| Weighing scales | Data not available |
| Ventilated cabinet | 1 |
| Centrifuge | 4 |
| Microhematocrit centrifuge | 2 |
| Colorimeter/spectrophotometer | 1 |
| Cell counter | 1 |
| CD4 counter | 2 |
| Hemoglobinometer | 4 |
| Blood bank | 1 |
| Refrigerator | 3 |
| Incubator | Data not available |
| Microscope | 4 |
| EIA analyzer | 0 |
| Xpert® MTRB/RIF | 0 |
| Water purification system | 1 |
| Other | 2 (Glucometer) |

rectifying the situation before procuring any other equipment, as EIA analyzers.

It is worth highlighting that even where a technology is present, it is often not well-maintained or functional. For instance, there is a CD4 counter at the Lui laboratory but workers cannot adopt it because it is located in a crumbling, dark room, making it useless. A similar situation exists at Pujehun laboratory, where microscopists must use an obsolete microscope-with damaged lenses – because there is not sufficient power to support the newly purchased one. Clearly, in this latter case an adequate, correctly sized, reliable power system – possibly based on solar energy, will have to be provided.

The finished model was then submitted to clinicians working with Doctors with Africa CUAMM, who accepted and validated it.

Considering that the model developed in this work represents the best setting any African health laboratory could aim for, it has been demonstrated that comparing the performance of actual laboratories with the standard allows deficits to be identified in the expected service and interventions to be subsequently prioritized. The model is also designed to evaluate the amount of financial resources to invest in order of priority: starting with basic, essential equipment and moving on to other specialized technologies [22].

However, to improve the quality of health laboratory services, other cornerstones need to be taken into account and developed [23]. First, it is fundamental to focus on staff training: nowadays laboratories are understaffed and there is an insufficient number of qualified personnel. Petti et al., reported that only 26% of 693 Ghanaian laboratory staff had a recognized degree [24] and, as reported by CUAMM, this situation is widespread in Africa. Hence the authors suggest that NGOs should support educational institutions in training laboratory technicians, assistants and technologists in the improvement of quality management systems and in accelerating laboratory accreditation [25]. In the near future, hospitals and laboratories could take advantage of "task shifting" practice: personnel such as nurses and midwives could be trained in some specific laboratory activities, thereby guaranteeing a basic health laboratory service [25].

The present work has highlighted the considerable difficulties encountered in tracking laboratory activities and their equipment inventory. Several efforts have to be made to file and manage data because it becomes very hard to programme interventions at health laboratories without correct, current information.

Procuring appliances and consumables – such as cuvettes, cartridges, and so on – is still a difficult issue: territorial geography, viability and transportation conditions, and poor stock management often cause discontinuities in health laboratory services. Hence interventions are needed in this field to avoid further wastage of resources.

Lastly, NGOs and institutions should collaborate to improve disinfection, sterilization and waste disposal procedures because current practices – e.g., recycling cuvettes and slides for different patients and burying contaminated materials – are not acceptable at hospital units.

Several authors have recently proposed to establish a pathway towards accreditation of health laboratories in limited settings [25]. This is chiefly based on the common idea that accredited facilities have the potential to improve the quality of patient health care by reducing errors in testing and consequently decreasing inappropriate treatment [26]. Nevertheless, as shown in the present work, there are lots of gaps to fill before starting with accreditation procedures. Only when the issues discussed herein have been solved can African health laboratories begin to seek accreditation.

The authors hope this work will mark the first step in this direction, allowing at least basic healthcare to be offered in the African region, with no wastage of resources and all the advantages technological progress has to offer.

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MISCELLANEOUS

# Point of Care Testing and Transfusion Safety in Resource-Limited Settings: A Review

Diagnostic laboratory tests have always had the disadvantage of being too expensive for use in countries with limited resources. There is now growing interest in a new form of lab tests that go by the name "point of care testing" (POCT).

POCT enables non-specialized health care personnel to carry out chemical analyses and immunology and hematology tests quickly and cheaply, making it probably one of the most suitable tools that can be used to meet the needs of low-income countries.

This study surveyed technologies that can be used in areas with little or no infrastructure and that do not require special servicing. They can be employed both in operating rooms and in complex emergency settings. An analysis of the strengths and weaknesses of POCT transfusion medicine shows the need for more accurate health care systems, in order to achieve high standard outcomes in transfusion medicine. However, it is impossible to develop effective new techniques for global health care without the involvement of local authorities and communities.

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# Point of Care Testing and Transfusion Safety in Resource Limited Settings: A Review

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**Abstract**

Worldwide, one of the fastest growing aspects of clinical laboratory testing is point of care testing (POCT). Decentralized patient care and access to testing in under-served areas are key elements in the evolving expansion of POCT. Several available POCT devices can potentially contribute to safer transfusion practices in resource-limited settings. Only "rapid diagnostic tests" and some simple hemoglobinometers are normally encountered in the peripheral hospitals of low income countries. Strengths, weaknesses and barriers of large scale utilization of POCT in transfusion medicine are discussed.

**Keywords:** Transfusion safety; Hemoglobinometers; Anaemia; Developing countries

## Introduction

There is a growing interest in new or rediscovered laboratory technologies that can be utilized without the presence of specialized personnel, at the bedside and/or in extreme field conditions, with limited or no infrastructure and without specialized maintenance services. Point of care testing (POCT) allows for rapid and accurate laboratory testing at the bedside where immediate and effective clinical decisions need to be made. This can be performed at community level, in operating rooms or in complex emergency settings. These diagnostic devices are increasingly recognized as appropriate in low and middle income countries, where human, financial and logistic recourses are scarce, and where there are major constraints in supply and maintenance services [1,2]. ASSURED the acronym that has been proposed to summarize the main criteria that define POCT devices stands for: affordable, sensitive, specific, user friendly, rapid and robust, equipment free and delivered [3]. The spectrum of available technologies varies from low-tech to high tech, and their effective introduction depends on the specific target product profiles [4], i.e. their intended settings. Examples of POCT devices that are increasingly utilized in high income countries include dry chemistry analyzers, rapid immunological tests, coagulometers and hematology analyzers. Other devices, like CD4 counters and Nucleic Acid Amplification Tests –NAAT-, are more specifically conceived for infectious diseases control programs in developing countries [5].

In the hospital setting blood transfusion is an essential treatment that is available worldwide; however the more current, sophisticated and high throughput technologies utilized in transfusion medicine in high income countries are hardly suitable for blood banks in resource-constrained health services. In these contexts few blood units are collected and transfused daily and often only in emergencies, therefore instruments and devices that allow single or small batch testing and rapid turnaround time are required. Global improvement in transfusion safety depends on technologies that can be safely operated in disadvantaged situations.

## Study Design and Methods

We examine the contribution of POCT in the four main areas of transfusion medicine: hematology, hemostasis, infectious diseases screening and pre-transfusion testing. We address strengths and weaknesses of POCT transfusion medicine, as well as factors that may influence their widespread implementation in resource-limited settings. PubMed was searched from January 1st, 1990, to February 28th 2014, with the terms "point-of-care" and "transfusion", "point-of-care" and "hematology" and "rapid tests" and "transfusion" for all available articles. We selected reports, reviews and, epidemiological studies published in English and we also reviewed references from selected publications. The titles and abstracts of each article *were screened for relevance* with regard to the limited-resource setting, the identified articles were retrieved for assessment of the full text.

## Results

507 articles were initially identified utilizing the search criteria. Further selection based on their relevance in the context of resource-limited settings reduced the number to 84 papers which were reviewed and organized according to the four areas of interest in transfusion medicine.

### Hematology

Rapid and reliable hemoglobin level testing is the cornerstone for appropriate blood transfusion and therefore represents the first step in the transfusion process. The Global Negleted Tropical Diseases (NTD) program launched the requirements for a method to measure

hemoglobin concentrations that should be accurate enough to detect the anticipated changes in haemoglobin levels induced by interventions for NTDs, should not require mains electricity, can be performed with minimal training and supervision and uses whole blood so that no dilution steps are required [6].

There are several options of POCT in hematology some of which have been marketed for decades. A review was recently published [7] which details the options available for POCT in hematology. Essentially they are divided in single parameter, i.e. hemoglobinometers, and multi-parameters analyzers.

Traditional and more recent "visual" hemoglobinometers, such as Shali, Lovibond and the Hemoglobin Color Scale, are simple devices which are however too subjective and inaccurate to correctly identify severely anemic patients that may require RBC transfusion [8-10]. A new POC visual method that can also be interpreted via smartphone has been recently tested and has given some promising results [11].

More sophisticated and reliable point-of-care photometric hemoglobinometers have been utilized for decades for POCT in different settings. The haemoglobin method that has been most widely used in NTD programmes is the HemoCue system. The HemoCue system® (HemoCue, Angelholm, Sweden) provides a reliable, rapid one-step haemoglobin determination with a sensitivity of 80–96·6% compared to standard laboratory methods [12,13]. The method utilizes dedicated microcuvettes suitable for direct hemoglobin determination from undiluted venous or capillary blood. The main advantages are that it uses battery power, is easy of use, accurate, provides rapid results, and is portable [14]. As well as being accurate the HemoCue method is robust and has an in-built quality checking tool [15]. New versions of these portable photometric analyzers, the HemoCue Hb 301 system and The DiaSpect Hemoglobin T system (DiaSpect Medical, GmBH, Sailauf, Germany) offer the additional advantage of utilizing "reagent free" microcuvettes that can be stored in high temperatures and in high humidity conditions, situations that are not uncommon in developing countries [16]. The main disadvantages of these portable hemoglobinometers are represented by their cost and scarce availability at the local level [17]. Another method, the Haemoglobin Colour Scale (HCS) has been designed for field situations in resource-poor countries and is considered to be better than clinical diagnosis in detecting anaemia in children and pregnant women [18,19]. The main disadvantages are the need for a specific type of chromatography paper as well as good natural light. The method is not able to detect incremental changes in haemoglobin less than 1 g/dl. The Lovibond comparator method is an alternative technique for measuring haemoglobin that does not require a dilution step, may have satisfactory precision and accuracy, but requires an exact volume of 0.03 ml of whole blood, which is difficult to achieve in field situations [20]. The Microhematocrit method is another cost-effective alternative for hemoglobin estimation. Although the method is sufficiently accurate and it utilizes fairly cheap consumables [21,22] it requires a basic laboratory infrastructure and a reliable power supply. More recently a portable hemoglobinometer that utilizes reagent strips was marketed offering another technological alternative. The TrueHb Hemometer, developed by Ambar Srivastava of the Indian Institute of Technology (IIT), is a relatively small device and represents the first case of an innovation by the biomedical engineering department of IIT-Delhi [23].

Noninvasive devices offer an appealing alternative for haemoglobin determination, however limitations in accuracy, especially in emergency situations such as hypovolemic shock, caution against their utilization as unique transfusion decision tools [24-26].

In recent years simple, compact and affordable multiplatform hematology analyzers that utilize impedance cell counting methodology and spectrophotometric hemoglobin determination have become available [6]. "Impedence" based counters require a supply of dedicated and relatively bulky "liquid" kits as well as regular maintenance and a reliable power supply. All these characteristics make these instruments less appropriate and manageable in remote settings. The microhematocrit based automated "quantitative buffy coat"–QBC-method offers an alternative to traditional multiparameter hematology analyzers. The main advantages of this system are that it is portable and relies only on "dry" reagents. This analyzer still has a fairly limited distribution and utilization in resource-limited settings [27] notwithstanding its simplicity and remarkable performance.

Finally as far as hemoglobinometers are concerned it should be mentioned that a rapid assessment of hemoglobin concentration is usually performed before bleeding the donor. In this context the accuracy of the test result is less critical and many of the basic abovementioned methods, including the simple Hemoglobin Color Scale, can play a role in the selection of blood donors in resource-limited settings [28,29].

## Hemostasis

Since blood components such as fresh frozen plasma and platelet concentrates are scarce in peripheral and resource limited settings, point-of-care devices and methods for coagulation and platelet function testing are only briefly presented in this review.

Simple bedside whole blood coagulation utilizing a dry tube is a basic and very simple method that was employed in the past to detect coagulopathy and is still utilized in cases of snake bites in Africa and elsewhere [30,31]. It has been demonstrated that a 20 minute whole blood clotting test -20WBCT– shows good correlation with fibrinogen concentration, however its clinical predictivity in the case of snake bites has been questioned [32].

In high income countries much more sophisticated devices for POC coagulation testing are available. Their main uses are the monitoring of vitamin-K antagonist oral anticoagulants, the assessment of platelet function, in particular in patients undergoing anti-platelets therapy, as well as the rapid evaluation of clotting function in bleeding patients during surgery and in emergency settings [33-37]. Out of these the viscoelastometric POCT devices are particularly useful in giving quick information on all the main phases and components of clot formation, including fibrinogen concentration, platelet activity and fibrinolysis [38]. For this reason they are utilized to guide the clinical management of acute coagulopathy that follows trauma and hemorrhages, including obstetric cases [39-41]. To our knowledge however there are no studies that document the utilization or the appropriateness of POC coagulation tests in resource-limited settings. As in the case of other more sophisticated POC devices cost and unavailability of supplies at local level are likely to represent major barriers to their utilization. As far as the management of coagulopaties is concerned, it is important to remember that in most peripheral hospitals in Sub-Saharan Africa whole blood is the only available blood product [42]. Fresh whole blood units, if available in sufficient number, are indeed an effective therapy in case of dilutional and consumption coagulopathy that follows severe acute bleeding and trauma since it rapidly restores

simultaneously red blood cells, active clotting factors and platelets [43].

### Transfusion transmitted infections -"TTIs"- screening

According to global standards all blood units must be tested at least for HIV antibodies – HIV, Ab- hepatitis B antigen S -Hb Ag-, Hepatitis C antibodies -HCV Ab- and Syphilis. Other infections, such as malaria and Chagas disease, can be screened according to the epidemiological context [44]. In high income countries immunoenzymatic or chemioluminescence tests are routinely employed for TTIs screening. These sophisticated and often automated laboratory platforms require constant maintenance, regular supply of dedicated reagents and controls and must be operated by skilled laboratory personnel. All these features make their utilization and reliable functioning difficult in resource-limited and/or remote settings.

Since the late eighties Rapid Diagnostic Tests - RDTs – have been available for HIV diagnosis, and have represented a breakthrough in transfusion safety in low income countries [45-49]. Since then RTDs have been devised and marketed for the diagnosis of all major TTIs, including HbSAg and HCVAb, and a review on their utilization for transfusion safety in Africa has recently been published [50]. RDTs comply with all the "ASSURED" criteria, and therefore the term RDT is commonly used to describe the POCT devices for infectious diseases diagnosis.

RDTs are essentially based on three main principles: immunochromatography, immunofiltration or immunoconcentration and agglutination. Among these the immunochromatographic strips – lateral flow or dipstick - are the most utilized, because of their simplicity and the possibility of single step procedure. The average cost of these tests is today down to a dollar or less. Additionally many of them can utilize capillary blood in place of serum/plasma and can be stored at room temperature. One of the main limitations of RDTs is that they are operator-dependant in several aspects: preparation, interpretation and recording of results. This can explain some discrepancies in reported test accuracy and represents an additional major shortcoming in high-throughput laboratories. Sensitivity of RDTs in TTIs screening is a major concern and this is obviously a crucial aspect in blood safety. As far as analytical sensitivity of HIV RDTs is concerned, as it is in the case of testing series of progressively diluted specimens, the limits of RDTs performance are evident when compared to reference immunoenzymatic tests [51,52]. When clinical sensitivity is considered however, i.e. observations on undiluted samples from patients or from blood donors, many HIV RDTs offer an acceptable level of detection of truly positive samples [45,48]. WHO sets precise standards for acceptability of HIV RDTs: sensitivity >99%, specificity >98% associated to inter-observer variability and invalidity rate both <5%. A list of commercial kits that comply with these standards is available and regularly updated [53]. Recently a "combined" HIV P24 antigen-antibodies RDT has been marketed with the objective of increasing sensitivity during the early stages of infection. The first independent observations however show a limited diagnostic value of this combo test in the seroconversion period [54].

As far as RDTs for HbSAg and HCVAb are concerned the reported clinical sensitivity is on-average lower than HIV RDTs [45,47,55-59]. The reason for this may be the higher proportion of relatively low-titer reactive samples and the longer window period in the early phases of infection. However also for HbSAg and HCVAb there are kits that show promising results in terms of diagnostic accuracy [60-65] and a HbSAg RDT has been recently CE marked as it achieves the requested sensitivity of at least 0.125 I.U/mL [66].

For all these reasons RDTs for the three major viral TTIs are considered an acceptable alternative for the screening of blood donations where immunoenzymatic tests are not available, i.e. in small peripheral laboratories and in emergency situations [53].

As far as syphilis is concerned Treponemal immunochromatographic RDTs are also available and can replace the more traditional agglutination non-treponemal essays.

In recent years RDTs for Malaria have gained a central role for the diagnosis of this disease, both in high and low-income countries. As blood screening tools RDTs may however fail to detect low grade parasitaemia in asymptomatic "semi-immune" adults, as "healthy" blood donors in malaria endemic countries may often be [67,68].

In general as far as the accuracy of RDTs in field conditions is concerned, it should be remembered that inappropriate storage conditions may heavily affect their performance and this can be a major problem in a tropical environment [69].

In high income countries multiplex nucleic acid amplification testing – NAAT- for HIV, HBV and HCV – is a mandatory additional screening tool. NAAT is able to reduce the infectious window period and therefore also the residual transmission of infectious diseases through blood transfusion. Technologies in molecular diagnostics have rapidly evolved in recent years but very few present operating characteristics that make them appropriate for utilization in peripheral locations of low-income countries. There are however promising NAAT platforms that simplify molecular testing by fully integrating and automating the three processes (sample preparation, amplification, and detection) required for real-time PCR-based molecular testing in a single cartridge containing all necessary elements for the reaction [70]. These instruments are simple enough to be performed reliably even by individuals without a background in nucleic acid diagnostics. Unfortunately no available POC NAAT platform yet includes, among the many testing options, kits for the combined screening of the three main blood-borne viruses. There are however promising and innovative NAAT technologies, such as the loop-mediated isothermal amplification assay (LAMP), with the potential to be sensitive, rapid and user-friendly enough to be utilized as a blood screening tool in remote settings [71].

### Pre-transfusion testing

Pre-transfusion tests, i.e. blood grouping and cross-match, are specific activities of blood bank laboratories. Traditional, simple and cheap ABO-Rh typing, utilizing commercial antisera, can be easily done at the bedside by trained health workers. Dry-reagent typing cards have been marketed for decades and offer an even more simplified typing procedure suitable for bedside blood group confirmation by ward staff [72,73]. Innovative paper based blood typing kits are also in the pipeline [74].

Together with ABO-Rh typing, however, WHO recommends the presence of at least the antiglobulin phase compatibility for a complete pre-transfusion testing [75]. Traditional antiglobulin crossmatch, in its tube version, is a relatively simple and affordable test. It requires essential laboratory equipment (low speed centrifuge, clean pipettes, water bath incubator, low power microscope, refrigerator) and reagents (sterile saline solution, antiglobulin serum). The procedure includes several critical steps and requires specific skills in

interpretation and in problem solving, especially in case of initially reactive results. According to most observations the antiglobulin test is hardly ever encountered in rural hospitals practice in low-income countries, and compatibility testing is generally limited to AB0-Rh typing, often accompanied by room temperature "major" cross-match [49,76].

Since the discovery of antiglobulin testing in the mid 20th century, a major "breakthrough" in immunohematology has been the introduction of gel microcolumn essays which allow a simplified indirect antiglobulin test, with fewer steps, and a more reliable and stable reading of results., The method however still requires specific laboratory skills, equipment and reagents and is therefore not compliant with POCT essential features.

## Discussion

As described there are several point-of-care laboratory technologies that are useful for a safe transfusion practice and appropriate in resource-limited settings. However out of these only serological "rapid diagnostic tests" and some simple hemoglobinometers are available in the field. As described no point-of-care antiglobulin phase pretransfusion tests or equivalent exist or are in the pipeline. Finally, notwithstanding the availability of innovative and simplified NAAT technologies, no POCT kit is yet available in the field of molecular testing of TTIs.

Several factors and barriers that affect the adoption and scaling up of POCT have been identified. These include economic, regulatory, policy-related factors, as well as user/provider perceptions and cultural barriers [4,77].

Recent experiences in the field of POC molecular diagnostics proved however that high-tech technologies can be disseminated globally thanks to a winning combination of elements: a public-private partnership, affordable and "negotiated" prices, a global supply and assistance network, and, not least, a global validation and performance monitoring program [70,78]. In other words a strong public health commitment and the contribution of non-profit foundations and international organizations are essential for a successful introduction of new health technologies on a global scale.

If the advantages of POCT in resource-limited settings are self-evident their limitations are also straightforward and must be carefully taken into account when these devices are introduced into clinical practice. Some of the potential disadvantages of POCT are the lack of standardization in obtaining blood samples, the need for additional training and supervision in order to minimize operator subjectivity and the lack of adoption of internal/external quality assessment tools. For these reasons as far as possible rigorous quality assurance procedures, including EQA -External Quality Assessment - should be applied, both for the prevention of procedural and clerical errors as well as for tests validation [79,80]. Moreover newly introduced POC tests and RDTs need to be locally evaluated before supply is established [81]. This is particularly relevant in the field of TTI testing since the quality of local samples, the genotypes and subtypes of circulating infectious agents and other factors may influence the performance of the essay

The problem of poor-quality and counterfeit diagnostics is also an emerging problem in resources-limited settings and health authorities should strengthen their regulatory oversight to the POC tests that are frequently distributed in developing counties [82].

## Conclusion

Blood Transfusions, even if limited to whole blood, are relatively sophisticated and high risk practices in under-resourced environments. The laboratory armamentarium currently available in the blood banks of high-income countries is in many ways impracticable and unaffordable in the majority of rural and remote hospitals in low-income countries.

Existing rapid tests for TTIs screening and portable hemoglobimomethers are POC tests that today contribute to transfusion safety in contexts where more complex and costly devices are unavailable; however more simple, accurate and affordable systems are needed in order to achieve higher standards in all aspects of blood safety in these settings.

Several prototypes are in the pipeline especially in the field of microfluidics and nanotechnologies [83], and in future some of these may prove useful in the field of transfusion medicine. However new technologies for global health cannot be effectively developed without the involvement of the end-users in low-income countries and an active bottom-up approach [84]. Whether these innovations will actually be disseminated and effectively utilized in resource-limited settings will probably depend not only on market dynamics but also on public health policies and funding.

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# The 2014 Ebola virus disease outbreak in Pujehun, Sierra Leone: epidemiology and impact of interventions


The 2014–2015 Ebola virus disease (EVD) epidemic in West Africa was first detected in March 2014 in Guinea and XXX , with a total of 28,220 reported cases and 11,291 reported deaths (WHO, September 2015).

Starting in July 2014, Doctors with Africa CUAMM worked to combat Ebola outbreak in Sierra Leone's Pujehun District, where it has been active with health projects since 2012. With 49 reported cases and an 85.7% mortality rate, on 10 January 2015 Pujehun was the first district in the country to be declared Ebola-free.

This article aims to analyze both the principal characteristics of the epidemic in the Pujehun District and the work done by Doctors with Africa CUAMM to combat it, in order to understand how it was successfully contained.

It discusses some of the most important steps taken, including contact tracing (the process of identifying and isolating suspected cases); the availability of an adequate number of hospital beds, which made it possible to hospitalize and isolate a much higher percentage (90%) of suspected cases in the Pujehun District than was the case elsewhere in the country (an average of 52%); and the speed with which containment actions were taken. For a health care system as weak as Sierra Leone's, the indirect consequences of the outbreak could have been much worse than the outbreak itself; however, thanks to the leadership that was shown in tackling the emergency, access to maternal and infant health care services did not decline in a significant manner during the outbreak.

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# The 2014 Ebola virus disease outbreak in Pujehun, Sierra Leone: epidemiology and impact of interventions

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## Abstract

**Background:** In July 2014, an outbreak of Ebola virus disease (EVD) started in Pujehun district, Sierra Leone. On January 10th, 2015, the district was the first to be declared Ebola-free by local authorities after 49 cases and a case fatality rate of 85.7 %. The Pujehun outbreak represents a precious opportunity for improving the body of work on the transmission characteristics and effects of control interventions during the 2014–2015 EVD epidemic in West Africa.

**Methods:** By integrating hospital registers and contact tracing form data with healthcare worker and local population interviews, we reconstructed the transmission chain and investigated the key time periods of EVD transmission. The impact of intervention measures has been assessed using a microsimulation transmission model calibrated with the collected data.

**Results:** The mean incubation period was 9.7 days (range, 6–15). Hospitalization rate was 89 %. The mean time from the onset of symptoms to hospitalization was 4.5 days (range, 1–9). The mean serial interval was 13.7 days (range, 2–18). The distribution of the number of secondary cases ($R_0 = 1.63$) was well fitted by a negative binomial distribution with dispersion parameter $k = 0.45$ (95 % CI, 0.19–1.32). Overall, 74.3 % of transmission events occurred between members of the same family or extended family, 17.9 % in the community, mainly between friends, and 7.7 % in hospital. The mean number of contacts investigated per EVD case raised from 11.5 in July to 25 in September 2014. In total, 43.0 % of cases were detected through contact investigation. Model simulations suggest that the most important factors determining the probability of disease elimination are the number of EVD beds, the mean time from symptom onset to isolation, and the mean number of contacts traced per case. By assuming levels and timing of interventions performed in Pujehun, the estimated probability of eliminating an otherwise large EVD outbreak is close to 100 %.

**Conclusions:** Containment of EVD in Pujehun district is ascribable to both the natural history of the disease (mainly transmitted through physical contacts, long generation time, overdispersed distribution of secondary cases per single primary case) and intervention measures (isolation of cases and contact tracing), which in turn strongly depend on preparedness, population awareness, and compliance. Our findings are also essential to determine a successful ring vaccination strategy.

**Keywords:** Computational model, Ebola, Key time periods, Transmissibility, Transmission chain

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## Background

The 2014–2015 Ebola virus disease (EVD) epidemic in West Africa was first detected in March 2014 in Guinea [1]. With a total of 28,220 reported cases and 11,291 reported deaths (as reported by the WHO on September 16, 2015), the largest EVD outbreak ever documented [2, 3], the disease showed its devastating potential. In July 2014, a local outbreak started in Pujehun district, Sierra Leone, and on January 10th, 2015, the district was the first to be declared Ebola-free by local authorities. The outbreak affected a very isolated region and, in particular, two small, strictly connected areas, namely Zimmi (a rural town) and Dumagbe (a village).

Early detection of cases, isolation, contact tracing, safe burials, population awareness, and compliance, all critical factors for mitigating or containing EVD, were implemented during the course of the epidemic in West Africa, albeit with different degrees of success. Nevertheless, the quantitative evaluation of their impact is still under debate. Most of the analyses conducted so far are based on time series of cases and on the scarcely available information about both local characteristics of EVD transmission and implemented intervention measures [4–7].

The EVD outbreak in Pujehun is considered a nearly unique example of a successfully contained outbreak in a rural and geographically isolated district. By combining epidemiological investigation and modeling techniques we aim to reconstruct the main characteristics of the outbreak and to evaluate the impact of the implemented intervention measures. This allows us to clarify the reasons behind the successful local containment of the epidemic.

## Methods

This study was conducted in Pujehun District, in the Southern Province of Sierra Leone and with a population of approximately 375,000 inhabitants. The district has one of the lowest population densities of Sierra Leone, with most people living in villages of less than 2,000 residents. The local healthcare system consists of one Government District Hospital with an 87-bed capacity and 74 Peripheral Health Units. Two Ebola Holding Centers (EHCs) were operative by the end of June 2014, one inside the Pujehun hospital, later moved outside the town, and the second one in Zimmi. The Sierra Leone Ethics and Scientific Review Committee approved the study protocol in July 2015. Collected data consisted of routine health data and medical records, were encrypted and anonymous, and did not contain any information that might be used to identify individual patients; therefore, the study did not require informed consent.

### Transmission chain

We reconstructed the transmission chain in Pujehun district by analyzing the registers of the two EHCs, contact tracing forms, and by interviewing healthcare workers (HCWs) involved in the management of the outbreak (three of them being co-authors of this study), survived case patients, and relatives of deceased case patients. We considered both confirmed and probable cases. Data on age, sex, date of symptom onset, hospital admission, and death/discharge were obtained from district health management team and registers of the two EHCs. An initial transmission chain was obtained by analyzing contact tracing forms (reporting the name of the contacts of primary cases, the relation between primary case and contacts, the date of the last contact, and the type of contact), available for 21 case patients. We filled the gaps in the initial transmission chain by discussing with authors CF, DB, and AK, who managed the two EHCs in Pujehun district during the outbreak and by discussing with survived case patients and relatives of deceased case patients – to this purpose, author GP visited the two villages at the end of the outbreak. No written informed consent was collected. Case patients and their relatives orally agreed to the interview. Information on individual patients has been anonymized for analysis, presentation, and dissemination of the results. A contact tracing form example is available in Additional file 1.

### Key time periods

We investigated the key times regulating infection transmission by analyzing the registers of the two EHCs (Additional file 2) and contact tracing forms. We estimated (1) the incubation period, which is the time from exposure to symptom onset (it is computed as the time from the last contact with the infector to symptom onset); (2) the time from symptom onset to hospitalization, a measure of the transmission period in the community for isolated case patients; (3) the time from symptom onset to death for unhospitalized cases (the term unhospitalized refers to EVD cases that died before or soon after arriving in the EHC of Pujehun district), a measure of the transmission period in the community for non-isolated cases; (4) the time from hospitalization to discharge or death, which are indicative of the number of EVD beds required for timely isolation of cases; (5) the serial interval, which is the time between symptom onset in a primary infector and in secondary cases. In this analysis we discarded all missing data by assuming that they were missing at random.

### Reproduction numbers

We analyzed the distribution of the number of secondary cases generated by all cases and we inferred estimates of the basic reproduction number $R_0$, which is the mean number of secondary cases generated by an index case introduced in a fully susceptible population. $R_0$

gives insight into the effort required to control the disease and when the reproduction number is below 1, the infection cannot be sustained. We also estimated the net reproduction number, $R_t$, which describes changes of $R_0$ over time due to variations of the transmissibility (e.g. behavioral changes of the population, effect of interventions). We estimated $R_t$ over time from the time series of the exposure times of case patients and from our estimate of the serial interval.

### Interventions

We gathered information on interventions by interviewing HCWs involved in the management of the outbreak and by analyzing contact tracing forms. We estimated the probability of hospitalization of EVD cases, the percentage of cases detected and isolated through contact investigation over time, and the probability of community burials over time. Traditional burials in Sierra Leone consist of a set of practices, including washing, touching or kissing the body of the deceased, which may promote infection transmission. Herein, we use the term community burials as opposed to safe burials, these being conducted by EVD burial teams following specific procedures (starting from the moment the teams arrive in the village up to their return to the hospital or team headquarters after burial and disinfection procedures) aimed at minimizing the risk of infection transmission during burial ceremonies. Of note, community burials may be either safe or unsafe depending on several factors, e.g. population awareness.

### Impact of interventions in Pujehun

We developed a microsimulation model of EVD transmission for Pujehun district. The model is an individual-based model similar to that used to describe the transmission of EVD in Liberia [7]. The progression of the disease is based on our estimates of the key time periods. The model accounts for all implemented intervention measures, namely hospital isolation of cases, safe burials, and contact tracing. Hospitalization triggers contact investigation and deceased hospitalized case patients are safely buried. Transmission parameters were estimated by assuming our estimates about probability of hospitalization, community burial, and contact tracing levels. The impact of all implemented interventions was estimated through a detailed sensitivity analysis.

Further methodological details are reported in Additional file 3.

## Results

### The outbreak

A total of 49 case patients, consisting of 31 confirmed and 18 probable cases, were registered between July 2014 and November 2014 in Pujehun District (Table 1).

**Table 1** Characteristics of probable and confirmed cases of Ebola virus disease in Pujehun district, Sierra Leone

| | Number (%) |
|---|---|
| Children (0–15 years old) | 8/49 (16.3 %) |
| Adults (16–64 years old) | 35/49 (71.4 %) |
| Females | 30/49 (61.2 %) |
| Healthcare workers (HCW) | 3/49 (6.1 %) |
| Admitted to hospital | 44/49 (88.8 %) |
| Deaths | 42/49 (85.7 %) |
| Community burials | 5/42 (11.9 %) |
| Cases imported from abroad | 9/49 (18.4 %) |
| In the local transmission chains | 39/40 (97.5 %) |
| Exposed in family/extended family | 29/39 (74.3 %) |
| Exposed in the community | 7/39 (17.9 %) |
| Exposed in hospital (patients) | 1/39 (2.6 %) |
| Exposed in hospital (HCWs) | 2/39 (5.1 %) |
| Touched the body fluids of the case (blood, vomit, saliva, urine, feces) | 6/31 (19.4 %) |
| Had direct physical contact with the body of the case (alive or dead) | 16/31 (51.6 %) |
| Touched or shared the linen, clothes, or dishes/eating utensils of the case | 23/31 (74.2 %) |
| Slept, ate, or spent time in the same household or room as the case | 20/31 (64.5 %) |

Of these, 19 (38.8 %) were male and 30 (61.2 %) were female. Mean age was 31.7 years (range, 3–85), and 14 case (28.6 %) patients were aged ≤15. The case fatality rate was 85.7 % (42/49, 95 % CI, 72.7–94.1). The time series of cases is shown in Fig. 1a.

### Key time periods

The mean incubation period was 9.7 days (range, 6–15 days). The mean time from the onset of symptoms to hospitalization was 4.5 days (range, 1–9 days), with no statistically significant changes over time. The mean time to death after admission to the hospital was 3.1 days (range, 0–8 days), and the mean time to discharge was 7.0 days (range, 3–12 days). The mean time to death after symptom onset was 6.6 days (range, 0–22 days) for hospitalized cases and 5.8 days (range, 1–9 days) for unhospitalized cases, and the mean time to discharge was 10.4 days (range, 1–15 days). The estimated mean serial interval was 13.7 days (range, 2–18 days). Estimates of the natural history are summarized in Table 2.

### Transmission chain

Nine EVD cases were imported into Pujehun district from July to November 2014 (Fig. 1b). Only one imported case resulted in an outbreak, the remaining eight imported cases generated a total of three secondary cases (Fig. 1b). The main outbreak involved two close areas, namely

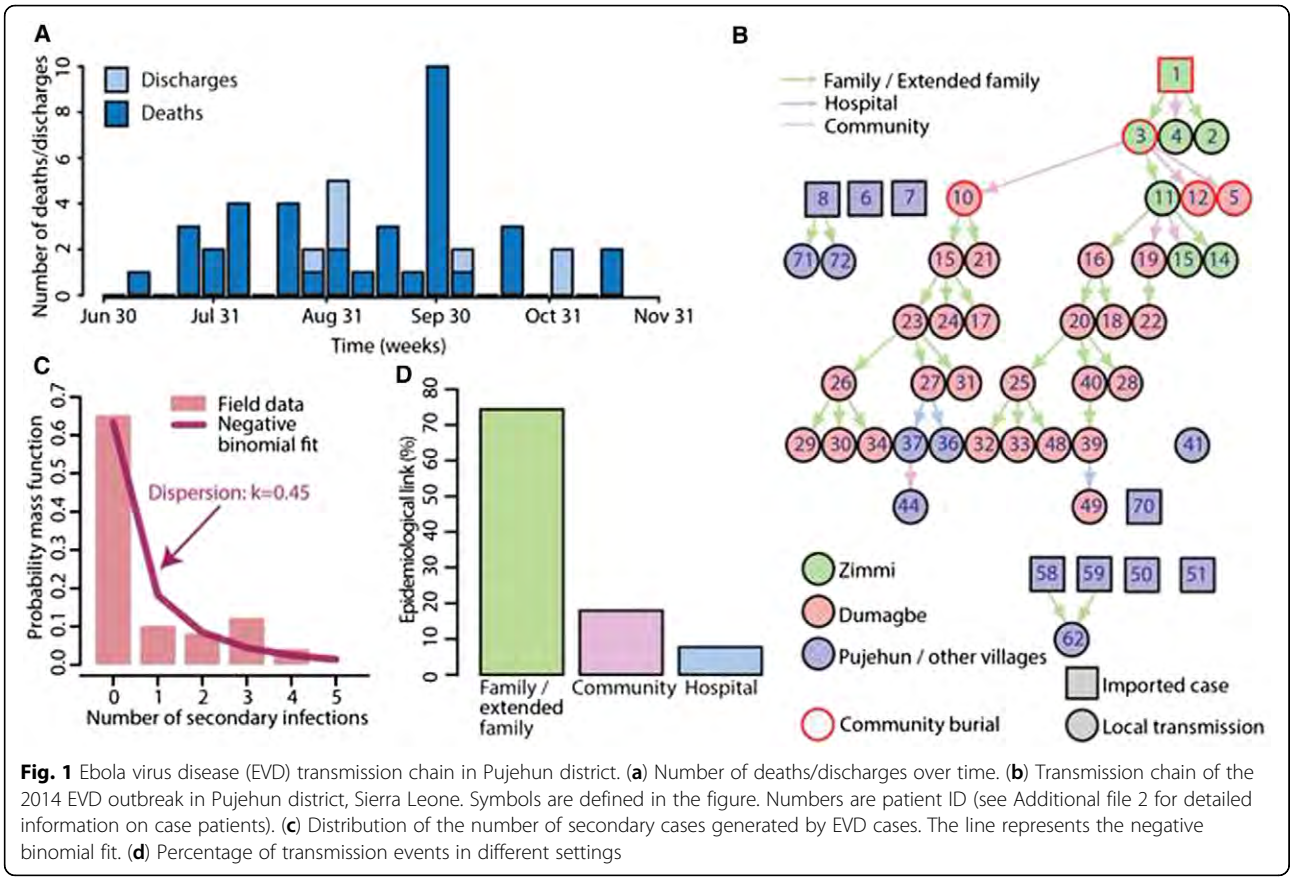


**Fig. 1** Ebola virus disease (EVD) transmission chain in Pujehun district. (**a**) Number of deaths/discharges over time. (**b**) Transmission chain of the 2014 EVD outbreak in Pujehun district, Sierra Leone. Symbols are defined in the figure. Numbers are patient ID (see Additional file 2 for detailed information on case patients). (**c**) Distribution of the number of secondary cases generated by EVD cases. The line represents the negative binomial fit. (**d**) Percentage of transmission events in different settings

Zimmi and Dumagbe, located in the Eastern part of the district, connected by family and commercial links; 39 out of 40 local transmission events were resolved. Six transmission events occurred in Zimmi and 27 in Dumagbe (Fig. 1b). The index case (patient ID: 1), a man escaped from the Ebola Treatment Center in Kenema and travelling to Zimmi, developed clinical symptoms on July 7, 2014, and died on July 11, 2014, without being isolated in Pujehun EHC and consequently infected two relatives (ID: 2 and 3) and one roommate (ID: 4), living in the same house as the index case in Zimmi. Patients 2 and 4 did not transmit the infection but patient 3 infected four persons, including the religious chief of Dumagbe (ID: 10) and one patient (ID: 11) who infected four persons, two of them living in Dumagbe (ID: 16 and 19). Thus, two different persons transmitted the infection in Dumagbe. Afterwards, the infection spread in Dumagbe in two separate chains of transmission exclusively through family contacts (Fig. 1b). The two transmission chains were sustained by few cases that infected three or four persons, while most of the cases did not transmit the infection (Fig. 1b). The number of secondary cases ranged from 0 to 4, and 65 % (32/49) of cases did not transmit the infection (Fig. 1b and c). The distribution of secondary cases is well fitted by a negative binomial distribution ($\chi^2 = 8.83$, $P = 0.07$) with dispersion parameter $k = 0.45$ (95 % CI, 0.19–1.32; Fig. 1c), while it does not comply with a Poisson distribution ($\chi^2 = 31.11$, $P < 0.001$), the expected distribution in case of homogeneous transmission. The mean number of secondary cases in the first month of the outbreak (first 8 cases) was $R_0 = 1.63$ (range, 0–4) (Fig. 1b). Overall, 74.3 % (29/39) of transmission events occurred between members of the same household or extended family (Fig. 1b,d), 17.9 % (7/39) of transmission events occurred in the community, mainly between friends

**Table 2** Estimated key time periods (median, mean, SD, range) and number of observations (N)

| | N | Median | Mean | SD | Range |
|---|---|---|---|---|---|
| Incubation | 8 | 10.0 | 9.7 | 3.7 | (6–15) |
| Symptom onset to hospital admission | 15 | 4.0 | 4.5 | 2.6 | (1–9) |
| Symptom onset to hospital discharge | 5 | 15.0 | 10.4 | 6.5 | (1–15) |
| Symptom onset to death in hospital | 19 | 5.0 | 6.6 | 5.9 | (0–22) |
| Symptom onset to death in community | 4 | 6.5 | 5.8 | 3.9 | (1–9) |
| Hospital admission to discharge | 5 | 9.0 | 7.0 | 4.3 | (3–12) |
| Hospital admission to death | 18 | 2.0 | 3.1 | 3.1 | (0–8) |
| Serial interval | 12 | 15.0 | 13.7 | 4.5 | (2–18) |

(Fig. 1b and d), and 7.7 % (3/39) of transmission events were healthcare related (Fig. 1b,d). Specifically, one driver (ID: 36) was infected during the transport of two EVD cases from Zimmi to Pujehun EHC, one nursing aide (ID: 37) was infected in the Pujehun EHC, and one patient (ID: 49) was infected in Zimmi EHC (the first test was negative and the second, 11 days after discharge, resulted positive). It was possible to establish the type of contact with the primary infector for 31 case patients (Table 1).

### Reproduction numbers

The model-based estimate of the basic reproduction number for Pujehun district in the absence of interventions was $R_0 = 2.24$ (95 % CI, 1.52–4.51; Additional file 3). The mean net reproduction number showed a decreasing trend over time (Fig. 2a). The mean estimated for the first month of the epidemic was $R_t = 2.24$. $R_t$ remained close to the elimination threshold from mid-August to mid-September 2014. After a raise of transmission in late September 2014, corresponding to the peak of deaths and discharges observed in the first week of October 2014 (Figs. 1a and 2a), $R_t$ permanently remained below the elimination threshold.

### Interventions

The percentage of unhospitalized cases was 11.2 % (5/49). A total of 71.4 % (30/42) of fatal cases were buried the same day they died (maximum delay between death and burial: 2 days) and 11.9 % (5/42) of fatal cases were buried in the community. Community burials were recorded only at the very beginning of the outbreak (Fig. 1b). Suspected EVD cases were hospitalized in two distinct EHCs with a capacity of 20 EVD beds overall; the number of patients hospitalized at the same time was never above 10. About 250 contact tracers performed contact investigation; the mean number of contacts investigated per EVD case raised from 11.5 in July to 16 in August, reaching 25 in September 2014. The mean (±SD) number of confirmed cases among traced contacts of cases was 1.9 ± 2.2, corresponding to a percentage of 16.6 ± 22.5 %. Overall, at least 42.5 % (17/40) of case patients infected through local transmission events were detected by contact tracing, an underestimate of the true value as it was based on the analysis of 21 contact tracing forms only. By assuming that detection (42.5 %) is proportional to the mean number of contacts investigated per EVD case, we estimated that the percentage of cases detected through contact tracing might have increased from about 30 % in July to 40 % in August and reached 60 % in September 2014.

### Impact of interventions in Pujehun

By assuming that case isolation is the only implemented intervention measure (90 % probability of hospital isolation and 4 days on average from symptom onset to hospitalization), we found that the probability of eliminating an otherwise large outbreak increased from 38.2 % (95 % CI, 36.0–40.3) to 73.6 % (95 % CI, 72.3–74.9) by increasing the number of EVD beds from 1 to 20 (Fig. 2b). The time from symptom onset to hospitalization had a dramatic impact on the probability of disease elimination (Fig. 2b). No large differences were observed by varying the probability of hospitalization between 50 % and 100 % (Fig. 2c). The above probabilities increased to 77.0 % (95 % CI, 75.8–78.2) and 99.0 % (95 % CI, 98.8–99.2), respectively, by additionally assuming contact tracing at the levels observed in Pujehun district since the beginning of the outbreak (Fig. 2d). The above probabilities decreased to 47.0 % (95 % CI, 45.1–48.9) and 89.5 % (95 % CI, 88.8–90.2), respectively, by assuming that contact investigation starts 60 days later (Fig. 2e). The results did not change substantially by assuming the availability of only five EVD beds instead of 20. We did not find a significant impact of safe burial procedures among unhospitalized cases on the probability of disease elimination.

## Discussion

The current EVD epidemic in West Africa has been generated by many local asynchronous outbreaks at district level [8]. In this respect, the Pujehun outbreak represents a precious opportunity for understanding detailed dynamical insights into the transmission of EVD, both concerning its epidemiological features and the assessment of control measure effectiveness.

Our estimates of the key time periods are coherent with the literature [3, 9]. The incubation period (9.7 days on average) might be underestimated as it is defined as the time from the last contact with the infector to symptom onset, the only available information (Additional file 2). Unfortunately, we did not have information about potential previous contacts – this information was not collected, as the aim was to define the follow-up period for contacts of cases. More in general, it should be kept in mind that data were collected under extreme conditions and estimates might be affected by the missing data. As for the time from symptom onset to hospitalization, our estimate (4.5 days on average) is similar to that observed in Sierra Leone (4.6 days on average) and West Africa (5.0 days on average) in the same period [3]. However, the observed high hospitalization rate, close to 90 %, and the early implementation of containment measures suggest a higher detection and isolation of cases, possibly resulting in an overall decrease of transmission in the community. This is ascribable to the availability of an adequate number of isolation units – 20 EVD beds in the two EHCs – and to an aggressive local policy of contact tracing – 25 contacts investigated per EVD case on average in September 2014. As for comparison, the percentage of isolated EVD cases in West Africa during the same period was 52 %

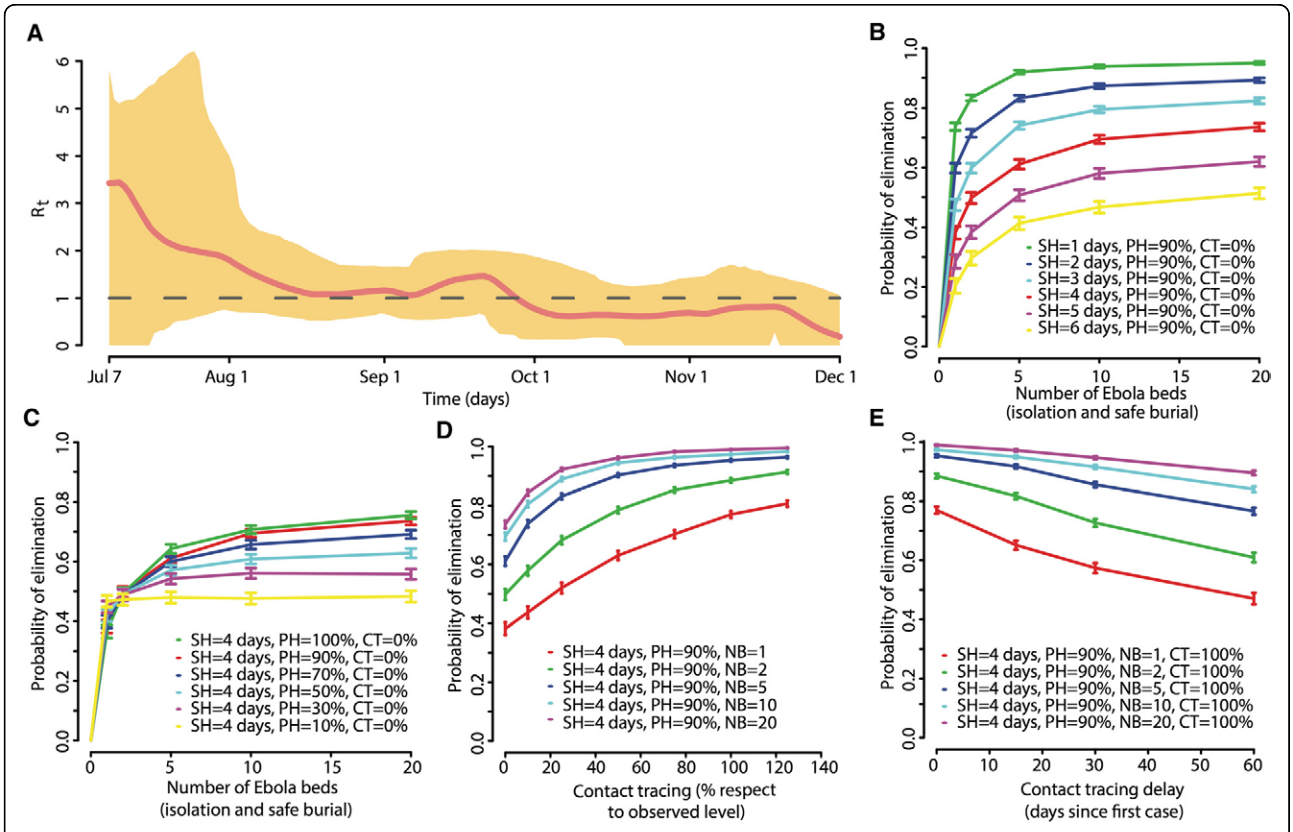


**Fig. 2** Impact of interventions in Pujehun district. The probability of eliminating an otherwise large outbreak is defined as $1–p_i/p_{ni}$, where $p_i$ and $p_{ni}$ are the probabilities of outbreak with and without intervention [19]. (**a**) Net reproduction number over time. (**b**) Probability of disease elimination in Pujehun district by assuming isolation of cases and by varying the number of Ebola virus disease (EVD) beds and the average time from symptom onset to hospitalization in the absence of other interventions (e.g. safe burials for unhospitalized cases and contact tracing). Probability of hospitalization set to 90 %. (**c**) Probability of disease elimination in Pujehun district by assuming isolation of cases and by varying the number of EVD beds and the probability of hospitalization in the absence of other interventions (safe burials for unhospitalized cases and contact tracing). The average time from symptom onset to hospitalization is set to 4 days. (**d**) Probability of disease elimination in Pujehun district by assuming isolation of cases and contact investigation and by varying the contact tracing levels (with respect to observed values in Pujehun district) and the number of EVD beds. Contact tracing level is defined as the percentage of cases detected and isolated through contact investigation, namely 30 % in July 2014, 40 % in August, and 60 % in September. The average time from symptom onset to hospitalization is set to 4 days and the probability of hospitalization is set to 90 %. (**e**) Probability of disease elimination in Pujehun district by assuming isolation of cases and contact investigation and by varying the timing of implementation of contact investigation and the number of EVD beds. The contact tracing level is set to values observed in Pujehun district, namely 30 % in July, 40 % in August, and 60 % in September 2014. The average time from symptom onset to hospitalization is set to 4 days and the probability of hospitalization is set to 90 %

(as reported by the WHO on November 5, 2014), while the target set by the WHO by 1 December 2014 was 70 %.

Model simulations support the relevant role of isolation of cases and contact tracing. By assuming that containment measures are implemented from the very beginning of the outbreak, we estimate that the probability of disease elimination could have been as high as 99.0 % (95 % CI, 98.8–99.2) as a combined result of isolation of cases and contact tracing as performed in Pujehun district. We found that 74.3 % of transmission events occurred between members of the family (a percentage about three times higher than that of influenza [10, 11]) or extended family and most of the remaining transmission occurred between friends – a pattern similar to that found in Guinea [12] and ascribable to the fact that EVD is mainly transmitted through unprotected physical contacts. Therefore, contact investigation could have been facilitated by close social and demographic relationships between cases.

Additional support comes from our estimates of the reproduction number. Our estimates (1.63 from the analysis of the transmission chain; 2.24 from the analysis of incidence) comply with those provided by other groups [3, 13–16], although it is very critical to compare estimates of $R_0$ for different geographical regions as they strongly depend on several factors, including individual behavior and control measures in place, among others.

Estimates of the serial interval are also similar to those provided by other groups [3] and of other hemorrhagic fevers, e.g. Marburg [17]. However, our estimates of the net reproduction number show a rapid decrease to values close to the elimination threshold less than 2 months after the first case. Elimination could have been facilitated by the overdispersed distribution of the number of secondary cases ($k = 0.45$, 65 % of cases did not transmit the infection) – it is well known that the probability of outbreak and elimination depends on the distribution of secondary cases per single primary case [18, 19] – and by the formation of clusters in the beginning of the outbreak (with high $R_t$ estimate).

Only one patient and two HCWs were infected in a hospital setting: this could have perhaps reflected adequate healthcare system preparedness, also witnessed by the early availability of 20 EVD beds and 250 contact tracers. The first local personnel training program started on April 2014, about 3 months before the first case registered. Indeed, a third HCW (one nurse of the Pujehun burial team) was infected during private treatment at the home of a friend, but we classified this event as transmission in the general community. None of the 74 Peripheral Health Units was closed during the outbreak and 10,285 childbirths were recorded in 2014 (without significant variations with respect to 2013, namely 9,657 childbirths). The relatively minor role of transmission during burial rituals appears to have been due to the aggressive local policy regarding funerals and the population's reportedly very good compliance of such.

In Sierra Leone, the proportion of EVD cases reporting having attended a funeral within 1 month of symptom onset has decreased from about 30 % in May–September 2014 to less than 20 % in October 2014–January 2015 [20]. In Pujehun district, community burials could have contributed to infection transmission only in the very initial phase of the outbreak. Other factors could make containment even more challenging in different areas; herein, the outbreak spread in a very isolated geographical area, thus making it easier to prevent the spreading to other villages (e.g. EVD checks at roadblocks around Zimmi and Dumagbe). The small population size of the two most affected villages contributed to successful contact investigation, which is likely more challenging in an urban context.

## Conclusions

The most important factors affecting the probability of disease elimination are the number of EVD beds and the percentage of cases detected and isolated through contact investigation. These factors strongly depend on preparedness (such as rapid medical supplies and organization of contact investigation procedures), population awareness, and compliance with intervention policies. Our simulations suggest that rapid implementation of these measures would also play a critical role, especially in cases of a suboptimal number of EVD beds and low contact tracing levels. Overall, a timely and aggressive activation of countermeasures appears to be decisive in the prevention of EVD outbreak scale-up to national or international level.

In their recent article, Henao-Restrepo et al. [21] demonstrated an efficacy of 100 % (95 % CI, 74.7–100.0) of the EVD vaccine candidate rVSV-ZEBOV and suggest that it might be effective at the population level when delivered through a ring vaccination strategy (vaccine effectiveness at ring level around 75 %). Our findings are relevant to evaluate the effects of the vaccine in containing an emerging EVD outbreak, as the outcome of ring vaccination policies strongly depends not only on the number of available doses, population compliance and timing of vaccine administration, but also on the ability of detecting cases and tracing their contacts.

## Additional files

**Additional file 1: contact tracing form.** (PDF 65 kb)
**Additional file 2: patient records.** (XLSX 44 kb)
**Additional file 3: additional methods.** (PDF 2635 kb)

### Abbreviations

EHC: Ebola holding center; EVD: Ebola virus disease; HCW: Health care worker.

### Competing interests

We declare no conflict of interest.

### Authors' contributions

MA, SP, SM, and GP conceived of the study. AK, DB, CF, and GP performed the epidemiological investigation. SP and SM performed the statistical analysis. MA developed the EVD transmission model and ran simulations. All authors contributed to the interpretation of the results. SM drafted the first version of the manuscript. All authors edited and approved the final manuscript.

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MISCELLANEOUS

# Ebola: lessons learned and future challenges for Europe

The Ebola epidemic that has ravaged West Africa – Liberia, Guinea and Sierra Leone in particular – since 2014 had led to more than 28,000 reported cases by October 2015, with implications not only for the health of communities involved, but also in terms of its impact on the region's economies and overall development and on international security.

Co-authored by public health experts working with institutions, research centers and non-governmental organizations, this article looks at some of the problematic aspects of the international community's handling of the outbreak, with a particular focus on the role of the European Community. These aspects – which included, but were not limited to, a lack of coordination among the countries involved as well as a failure to intervene in a timely manner – led to a response that was not nearly as effective as it could have been, highlighting the need for institutions, humanitarian organizations and governments to think about ways to improve Europe's role should similar circumstances arise in the future.

# Ebola: lessons learned and future challenges for Europe

*GianLuca Quaglio, Charles Goerens, Giovanni Putoto, Paul Rübig, Pierre Lafaye, Theodoros Karapiperis, Claudio Dario, Paul Delaunois, Rony Zachariah*

**The Ebola virus epidemic has topped media and political agendas for months; several countries in west Africa have faced the worst Ebola epidemic in history. At the beginning of the disease outbreak, European Union (EU) policies were notably absent regarding how to respond to the crisis. Although the epidemic is now receding from public view, this crisis has undoubtedly changed the European public perception of Ebola virus disease, which is no longer regarded as a bizarre entity confined in some unknown corner in Africa. Policy makers and researchers in Europe now have an opportunity to consider the lessons learned. In this Personal View, we discuss the EU's response to the Ebola crisis in west Africa. Unfortunately, although ample resources and opportunities for humanitarian and medical action existed, the EU did not use them to promote a rapid and well coordinated response to the Ebola crisis. Lessons learned from this crisis should be used to improve the role of the EU in similar situations in the future, ensuring that European aid can be effectively deployed to set up an improved emergency response system, and supporting the establishment of sustainable health-care services in west Africa.**

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## Introduction

Although the Ebola outbreak seems to be on the decline, it is still far from being over, with sporadic cases still being documented.[1] As of October, 2015, more than 28 000 cases have been reported, with an estimated case-fatality rate of roughly 50%.[1] Guinea, Liberia, and Sierra Leone were the most affected countries; Italy, Mali, Nigeria, Senegal, Spain, the UK, and the USA have previously reported at least one case imported from a country with widespread transmission.[1] Additionally, roughly 10 000–15 000 survivors report severe sequelae after the disease, including visual problems, abdominal and epigastric pain, insomnia, and headache.[2] The epidemic has rapidly eroded basic health infrastructure and has resulted in a substantial decline in the capacity of health systems to carry out preventive activities. A decrease in the use of routine medical services, such as vaccinations and paediatric and maternal admissions, has been reported.[3] Reduction in the delivery of malaria care because of the Ebola virus epidemic has threatened malaria control.[4,5] The decrease in health-care capacity, along with the socioeconomic effects of the sustained epidemic, has transformed the disease outbreak into a humanitarian medical crisis.[6]

At the beginning of the disease outbreak, European Union (EU) policies to address a large-scale Ebola epidemic, which could be potentially dangerous for EU countries even though it happened mainly outside EU borders, were not well articulated. Subsequently, during the crisis, the inability of the EU to mobilise human, financial, medical, and military resources in the regions worst affected quickly became evident to the public and the international community.[7] In a workshop held at the European Parliament on March 4, 2015,[8] an agreement was reached that the Ebola crisis will undoubtedly change how Ebola virus infection is viewed by the European public. The crisis should now compel the scientific community to better understand this virus and its effects, and ensure that the EU is better able to respond to similar crises in the future. In this Personal View, we discuss the EU's response to the Ebola crisis in west Africa, the lessons learned, and implications for the EU. We highlight the need to better define the EU's responsibilities in a global health emergency, redefine the military's role when public health is overwhelmed, establish a European team of health experts that can be deployed at short notice, revisit the EU policy in drug development research, and better use the capacity of humanitarian actors in the future. Finally, we explore how health-care systems can be sustainably financed in the three affected west African countries.

## EU actions in the fight against the Ebola epidemic

After what can be termed a sluggish start at the onset of the crisis, the EU stepped up its efforts through the appointment of an Ebola Coordinator, an increase in funding, and deployment of more medical and support staff to west Africa. The total EU financial contribution up to July, 2015, was around €1·8 billion, which included funding from individual EU member states and more than €869 million from the European Commission.[9] Moreover, numerous EU member states provided support through in-kind assistance (eg, personal protective equipment, vehicles, and field hospitals), which is not included in the above figure. This financial contribution supported humanitarian assistance, developmental aid, and medical research, and mainly targeted Guinea, Liberia, and Sierra Leone.[9] Since the crisis began, the Innovative Medicines Initiative has funded research projects worth €215 million,[10] and the European Commission has mobilised €24·4 million from the Horizon 2020 programme[9] specifically for medical research.

One of the first actions of the EU was to initiate the European Mobile Laboratory Project (EMLab) in March, 2014, which seeks to establish diagnostic facilities in the three main affected countries to support patient

For **EMLab** see http://www.emlab.eu/

screening and training of health-care workers. This project operates under the supervision of the WHO Global Outbreak Alert and Response Network. A new mobile laboratory, EUWAM-Lab, which is more self-sustaining than the ones established at the beginning of the project, was set up in Guinea in March, 2015.[11]

The European Centre for Disease Prevention and Control (ECDC) has been continuously monitoring the course of the outbreak since it began, including assessment of the risk of importation of the disease into EU territory, the risk of it spreading within member states, and the risk for EU travellers and residents in the affected areas of west Africa. The ECDC published several key papers describing noteworthy aspects of the Ebola outbreak in west Africa, such as the early transmission dynamics of the virus, the activities of the case management centres, the proportion of health-care workers infected, the transmission tree, and direct experiences from the field, among others.[12]

The EU also set up an evacuation system, with its member states providing the relevant resources, for infected international health-care workers. As of Sept 18, 2015, 38 people with Ebola virus disease or high-risk exposure to the virus have been evacuated from west Africa to Europe.[13] The EU Civil Protection Mechanism, an EU framework for cooperation in disaster management, helped with the delivery of emergency supplies (eg, food aid, medical kits, and clean blankets) from member states to the three most affected countries.[14] The European Commission also created a coordination task force bringing together EU member states, Commission departments, the European External Action Service (EEAS), representatives of the UN, the Red Cross, and non-governmental organisations to improve coordination in the field.

For its part, the European Parliament has drawn substantial attention to the Ebola outbreak on the political front. Since March, 2014, Members of the European Parliament (MEPs) have sent several Ebola-related parliamentary questions to the European Commission. On several occasions, the Development Committee of the European Parliament has stressed that the EU, a key donor of developmental aid globally, has a special responsibility to promote the universal right of access to health care, especially in light of the fact that 2015 has been designated the European Year for Development.[15] The Development Committee has highlighted the need to invest in the health systems of Guinea, Liberia, and Sierra Leone. Increased attention to the post-Ebola phase, to help these countries to recover through programmes similar to the Marshall Plan, has also been called for by the MEPs Linda McAvan and Charles Goerens.[16]

## EU shortfalls and lessons learned

WHO was severely criticised for a slow and fragmented response to the Ebola crisis; critics note that the international failures in governance and leadership will need to be corrected to avoid similar situations in future outbreaks.[17] Although the EU is an international institution with a different profile from that of WHO, it too needs to learn from this crisis. Despite the unprecedented scale of the epidemic and calls for action by the international community, public visibility and the reaction of the EU were lacking because of insufficient capacity to rapidly mobilise resources and the absence of structures to coordinate actions needed to help with outbreak response efforts.[7,18]

In spite of initial efforts to act, it was not until September, 2014, that substantial and coordinated EU actions were actually taken. The European Council sent a strong signal to both member states and the European Commission with the appointment of Christos Stylianides (European Commissioner for Humanitarian Aid and Crisis Management) as the EU Ebola Coordinator. His role was to ensure that EU institutions and member states acted in a coordinated manner with each other and with international partners. The broad mandate of Commissioner Stylianides has been a real test of leadership for all European organisations working during the Ebola crisis. Several challenges existed, particularly in the establishment of long-term developmental aid to west African countries. Speaking for the first time in his new role, Commissioner Stylianides admitted that "the international community [...] underestimated the danger and the extent of the threat".[19]

The slow reaction also revealed a weakness in the coordinating mechanisms between different EU institutions, military forces, research centres, non-governmental organisations, and other stakeholders to initiate a concerted emergency response. In the future, numerous EU institutions and departments can potentially be involved in a humanitarian medical crisis, including the European Commission's Directorate-General for International Cooperation and Development (DG DEVCO), responsible for the formulation of European cooperation and development policies; the European Commission's Humanitarian Aid and Civil Protection department (DG ECHO), committed to the provision of disaster response; the EEAS, the EU's diplomatic service that implements foreign and security policies; the European Commission's Directorate-General for Health and Food Safety (DG SANTÉ), responsible for the implementation of EU laws on health issues; and finally the ECDC, aimed at strengthening Europe's defences against infectious diseases. Clearly, it is not the institutions that are absent but the imperative to get them to work together rapidly in a global humanitarian crisis.

## Future challenges

To bolster emergency response capabilities and revamp the crippled health-care systems in the most affected

west African countries, much work remains to be done. The EU's mandate to implement a specific policy in a public health emergency (such as the Ebola crisis) should, in our view, include the following actions. First, the EU's responsibilities in global health emergencies need to be clearly defined. Since the creation of EEAS in January, 2011, the Crisis Response and Operational Coordination Department (CROC) has been commissioned to ensure the coordinated and synergistic response of the EU to external crises, by mobilising different EU departments and services. However, this coordination department does not seem to have received sufficient support and remains more a principle than a practice. In parallel, ECHO's Emergency Response Coordination Centre (ERCC), established in May, 2013, is a reference hub and focal point for EU member states, key international organisations, and other EU organisations to coordinate efforts in response to humanitarian crises and natural disasters.[20] ERCC seems to be best positioned as a major player in crisis management, because the Commissioner for Humanitarian Aid is also responsible for crisis management and has inter-institutional responsibility.

Second, the military's role needs to be redefined when public health systems are overwhelmed. By contrast with the EU, the USA was able to deploy thousands of soldiers in a short time to west Africa.[21] In the meantime, Europe acted in a fragmented manner: France and the UK sent military forces to Guinea and Sierra Leone, respectively, while some other EU member states set in motion their processes to assist with (military) logistics and supplies on the ground.[7] EEAS, with its EU military staff, seems to be well positioned to access military assets of member states in an effective and coordinated way, and to ensure that military interventions are in line with EU foreign policy for the countries concerned.[22]

Third, a pool of European medical and scientific teams—including public health experts, laboratory support teams, epidemiologists, clinicians, and medical staff—need to be established so that these teams can be deployed at short notice. Even before the Ebola epidemic (which resulted in nearly 500 health-worker deaths[23]), the density of physicians per 1000 population in the affected countries was striking, with 0·1 in Guinea, 0·022 in Sierra Leone, and 0·014 in Liberia, compared with 2·9 doctors per 1000 population in Belgium.[24] Cuba sent hundreds of health personnel to west Africa in October, 2014, a time when Europe was still discussing the best approach to implement on the ground.[25] During the Ebola crisis, several EU member states proposed the creation of a reserve pool of medical teams that could be deployed rapidly as part of a coordinated EU operation in future crises.[26] The idea was endorsed by the European Council, which on several occasions called on the European Commission and member states to further explore this issue.[27] The hope was that this input will allow the EU to start using all the mechanisms that are already in place, such as the voluntary pool of the EU Civil Protection Mechanism, to be well prepared for future crises.[28] The EU reserve pool mechanism will require close collaboration and complementarity with the Global Health Emergency Workforce developed by WHO.[29]

Fourth, the Ebola crisis should also be an opportunity to revisit EU policy and advocacy in drug development research. A vaccine would probably already be available if the disease had affected people in high-income countries, since the issue would have been attractive to drug companies.[30] John Ashton, president of the UK Faculty of Public Health, once said "We must also tackle the scandal of the unwillingness of the pharmaceutical industry to invest in research [on] treatments and vaccines, something they refuse to do because the numbers of cases involved are, in their terms, so small and don't justify the investment".[31] The European and Developing Countries Clinical Trials Partnership, which is part of the Horizon 2020 programme, plays an important part in supporting clinical research and capacity building in African countries, although the question of how to bring pharmaceutical and biotechnology partners on board remains unaddressed.[32] Initiatives and activism by the EU in this area are urgently needed.

Fifth, discussions around how to better use the capacity of humanitarian actors in the future are important. In the first few months of the Ebola crisis, humanitarian non-governmental organisations were the most effective players, since they were better informed and more able to act as leaders in the field than WHO and governments. For example, WHO is now using Médecins Sans Frontières' model logistics in countries still affected by the disease outbreak.[33]

Finally, a vision that links emergency interventions with medium-term developmental work needs to be created. The EU response should be two-fold: first, to support the economic recovery of the three main affected countries;[10] second, to provide developmental aid that is mainly focused on revamping the crippled health-care systems.[34] The economies of Guinea, Liberia, and Sierra Leone had been growing rapidly in recent years. However, as a result of the Ebola outbreak, output in these three countries declined in 2015.[35] The loss is estimated to be more than US$1·6 billion, which is more than 12% of their combined gross domestic product.[35] These countries have now fallen into recession because the Ebola epidemic has largely paralysed economic activity. The European Development Fund for the three countries will have to be reviewed in light of the many challenges that have emerged during the disease outbreak. Therefore, the mid-term review of the EU Multiannual Financial Framework should take into account the effects of the

crisis. Of note, the EU and its member states, the largest donors of official development assistance (ODA) globally, gave €56·5 billion of aid to low-income and middle-income countries, which amounted to 52% of the total global ODA in 2013.[36] As such, they should be able to provide specific support to the affected west African countries.

## Conclusions

The Ebola epidemic has reached unprecedented levels, with far-reaching humanitarian implications and implications for development, health, economics, and security. Although the EU and its member states had the resources and opportunities for effective humanitarian and medical action during crises, they did not coordinate an effective response. The Ebola epidemic, particularly in its first phase, revealed the gap between opportunity and much-needed action. We believe that lessons learned during this crisis can be broadly applied beyond the management of the Ebola outbreak—so that the EU can establish an improved emergency response system for future epidemics, and contribute to sustainable health care in west Africa. The EU should now play its part with courage and vision.

**Contributors**

All authors conceived the manuscript, contributed to its revision, approved the final version, and agree to be held accountable for all aspects of the work. GQ, GP, PL, and RZ obtained data and collated published work. GQ, CD, and PD analysed the data and reviewed the literature. GQ, CG, GP, PR, TK, and RZ drafted the manuscript.

**Declaration of interests**

We declare no competing interests.

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The views expressed in this Personal View are the sole responsibility of the authors and do not necessarily reflect the views of the affiliated organisations.

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# INFECTIOUS AND TROPICAL DISEASES

## ORAL PRESENTATIONS

# Tuberculosis Detection in the Napak District of Karamoja: the Role of GeneXpert

**Thematic Areas: TB and Laboratory Services**


**Author**

*Ictho J.[1], Massavon W.[2], Lochoro P.[3], Cipriano S.4, Sali P.[5], Nsubuga J.B.[5], Kyemeli N.[5] and Putoto G.[6]*

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**Background:**

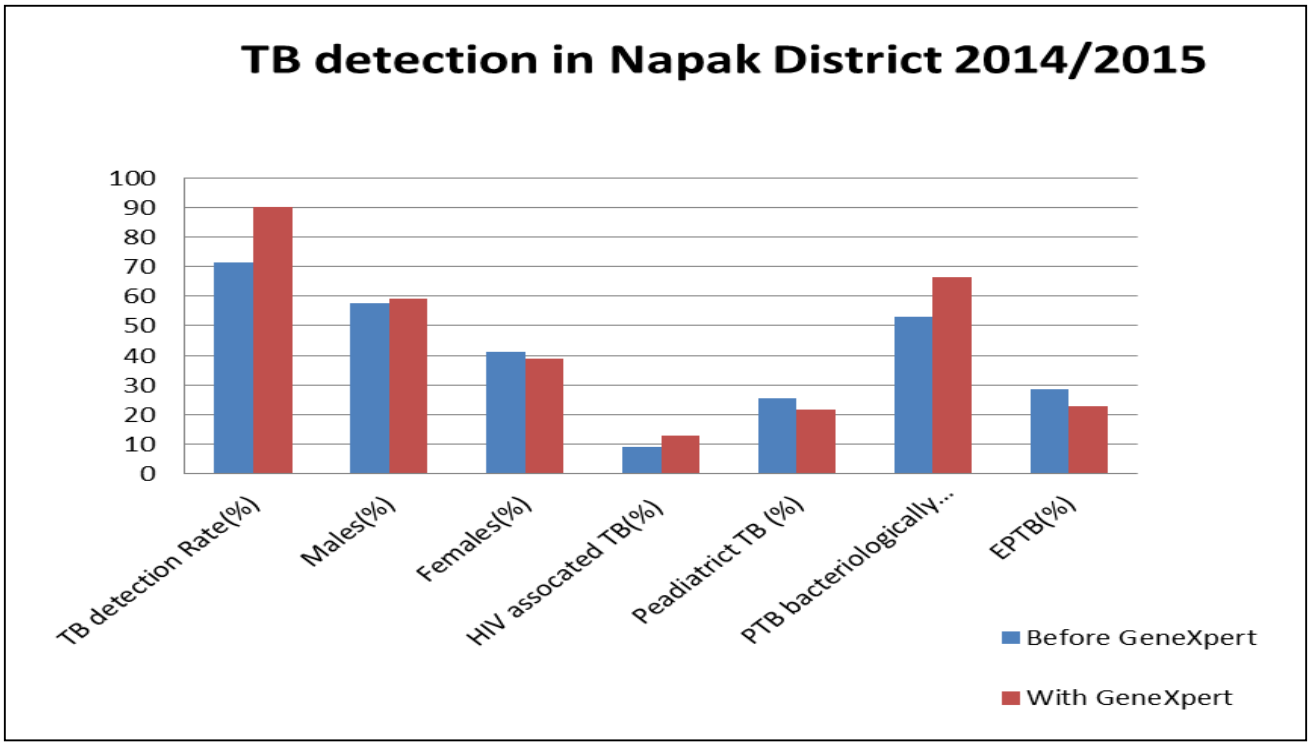
Tuberculosis (TB) is associated with significant mortality, morbidity and poverty in Uganda. Yet, TB detection remains suboptimal, particularly, in the rural settings. We evaluated the effects of the GeneXpert (Xpert MTB/RIF) diagnostic test on TB detection in the Napak district of Karamoja.

**Methods:**

We reviewed available records on TB diagnosis within Matany hospital, and 13 health centres implementing the GeneXpert diagnostic test in Napak district for 10 months (October 2014- July 2015). We used a data extraction questionnaire to collect baseline and endline data on TB detection. We then compared TB detection rates five months before and with implementation of the GeneXpert diagnostic test. Study outcomes included TB detection rates overall, by sex, in HIV-TB coinfection, in children, and in confirmed pulmonary TB (PTB) and extra pulmonary TB (EPTB) cases. We analysed the data using statistical package for social scientists (SPSS) version 16.0.

**Results:**

Overall, TB case detection rate was 82.6% (476 / 576). Of that, 58.6% were males. TB detection rates before and with GeneXpert implementation were 71.6% and 90.3% respectively ($p < 0.003$). TB detection improved from 9.0% to 12.8% for HIV associated TB ($P < 0.046$), and from 52.9% to 66.4% for bacteriologically confirmed PTB ($p < 0.003$). In contrast, paediatric TB case detection decreased by 3.8% from 25.6% to 21.8% with GeneXpert use ($P< 0.329$). These results are illustrated in the figure below.




**Conclusion:**

The Gene Xpert diagnostic test significantly increased TB detection in Napak district and could improve TB control, if scaled up.

**Key words:** TB; Detection; Gene Xpert; Xpert MTB RIF; Matany; Napak, Karamoja

# INFECTIOUS AND TROPICAL DISEASES

## POSTER PRESENTATIONS

**ICASA 2015**

- **Place of presentation**
  Harare
- **Date of presentation**
  29th November
  4th December 2015
- **Info**
  Damiano pizzol,
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MOZAMBIQUE

**ICASA 2015**
Harare, 29th November - 04th December 2015

# HIV and adolescents: keep calm and take care of them! The Friendly health services for young and adolescents (SAAJs) experience

*Damiano Pizzol [1], Guillermo Marquez[2], Graciana Pita[3], Arturo Silva[1], Michela Romanelli[4], Giovanni Putoto[5], Alexandra George[1]*

## Background

Mozambique has the fifth highest prevalence of HIV in the world, with 11.5% of the 15–49 years old infected population. Around 25% of people living with HIV are young people and 50% of HIV new infection in adults take place among those aged 15–24. Many factors has contribute to this vulnerability, including a lack of knowledge about HIV/AIDS, lack of education and life skills, poor access to health services and commodities, early sexual debut, early marriage, sexual coercion and violence, trafficking and growing up without parents or other forms of protection from exploitation and abuse. SAAJ are integrated and specialized health services for adolescents and young people aiming to improve health education, besides access and health care

## .Objective

To assess adolescents access, utilization and services provided about HIV by SAAJs supported by Unicef and Doctors with Africa CUAMM.

## Materials and Methods

We analyzed, in a retrospective study the data collected in 2011, 2013 and 2014 in registers from 4 SAAJs in Beira, Mozambique.

## Results

We observed a constant increase in adolescents attending SAAJ in 2011, 2013 and 2014 (23.302, 43.959 and 56.270 respectively). Also the percentage of HIV consultations increased from 54% to 76% (2011 vs 2014) of the total. Again, there was a marked and continuos increase of young people undergoing HIV test (6.900, 22.211 and 31.083). Among tested subjects, the number of positive ones did not increase significantly and, therefore, the percentage is considerably decreased from 18.3% to 4.6% (2011 vs 2014). Finally, the adolescents condoms demand progressively increased (10.784, 17.306 and 31.404).

Figure 1. Young trained activists at work in a SAAJ

## Conclusions and Recommendations

Young people health is one of the main predictors for the future of any country, however, many countries have not established policies for the prevention, early diagnosis and treatment of adolescents. Our experience in Beira pointed out that young people want to be informed and take advantage of the services they have available. In particular, it is growing the awareness of HIV infection as health risk and the desire to learn more and to know their own HIV status. The higher condoms demand means that HIV and STDs are perceived as avoidable risk factors. All these observations, on one side give hope in fighting HIV and on the other side suggest that it is a must to increase youth services.

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www.icasa2015zimbabwe.org

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# UNIVERSAL COVERAGE, FINANCIAL PROTECTION AND EQUITY

## ORAL PRESENTATIONS

# UNIVERSAL COVERAGE, FINANCIAL PROTECTION AND EQUITY

## ORAL PRESENTATIONS

# Effectiveness of Demand-side Incentives on Utilisation of Delivery Services in Oyam District, Uganda: A Quasi-Experimental Study


## Author

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## Introduction and objective

The days and weeks following childbirth – the postnatal period – is a critical phase in the lives of mothers and newborn babies. Most maternal and infant deaths occur during this time[1]. In this period, neonatal hypothermia is an important challenge associated with morbidity and mortality[2]. Hypothermia increases the newborn's metabolic requirements and is associated with hypoglycemia, hypoxia, and ultimately severe infections and newborn mortality[3]. Preventing neonatal hypothermia is important in high resource countries, but is of fundamental importance in low resource settings where supportive care is limited. For the postnatal care of the newborn, the World Health Organization (WHO) guidelines state: *"Appropriate clothing of the baby for ambient temperature is recommended. This means one to two layers of clothes more than adults, and use of hats/caps".* Whenever possible, KC is also strongly recommended for temperature maintenance[4]. Previous studies show that neonatal heat loss following delivery may be reduced or prevented by the application of simple woolen hats[5-7].On the other hand, also hyperthermia should be avoided[8]. Although WHO guidelines recommend the use of cap/hat during KC, the effect of the cap on neonatal temperature during the days and weeks following childbirth has not been previously studied. It's unknown whether covering the head of the neonate with a wool cap during KC may help temperature maintenance. The results of the present study will allow to understand whether the use of a cap during KC will be effective and safe. The aim of the present study will be to assess the effectiveness and the safety of a woolen cap in maintaining normothermia in low birth weight infants (LBWI) during KC.

## Material and methods

This is a multi-center, prospective, unblinded, randomized clinical trial of KC treatment with and without a woolen cap in LBWI that will be run through a collaboration of the Department of Women and Children Health, University of Padua and Doctors with Africa CUAMM, a nongovernmental- organization that works to strengthen healthcare services in Africa.

The study will be conducted in three hospitals that have different levels of healthcare in three African countries and three different attitude to Kangaroo Care (well established, medially established and not established yet) where Doctors with Africa CUAMM has ongoing projects on maternal-neonatal health.

# Training young doctors in Africa. Experience of non formal education for Italian medicine students

**Autori**
*Cavagna Chiara - Medici con l'Africa Cuamm; Di Benedetto Chiara - Medici con l'Africa Cuamm*

## Objectives

> To fill the gap between academic training and medical practical experience in the field;
> To give to medical students a reference model of medicine in contests with limited resources;
> To increase the students skills, stimulating them to experience their future job in different contests even before concluding their educational path;
> To ameliorate the relationship between Universities and Non Governmental Organizations work, in order to widen the students professional and cultural horizons.

## Methodological Approach

With the need to train a future medical class able to face health challenges of globalization, and with the willing to adjust university curricula in order to answer to the new needs of the identities of medical doctors, Doctors With Africa Cuamm has been proposing for ten years an innovative professional path –built with some Italian universities - which allow medical students and newly graduated doctors to experience a practical traineeship in the African countries where the organization is present: the "Wolisso Project". Thanks to this project, students observe, listen and learn by seeing the everyday life of a context with limited resources, and are immersed in a kind of medicine completely different from the Western standards to which they are accustomed.

## Results

> Applications from students willing to participate at the project have been exponential growing in the last ten years: 177 students left since 2005
> In 2015, there are plans for 48 students to leave for this experience (four students each month: two to Wolisso - Ethiopia - and two to Tosamaganga - Tanzania)
> A raising number of Italian universities asked to join the initiative and there are now 37 Universities promoting the project.
> Positive acknowledgements declared by participants both at the conclusion of the experience and three years after the traineeship.
> International recognition as the third best project in the world for medical students, received at the Project Presentation of the General Assembly of IFMSA, International Federation of Medical Students' Associations, in Baltimore in 2013.

## Conclusion

Cooperation between Doctors With Africa Cuamm and Italian Universities allowed to create an harmonious training path, able to mix theory and its practical application, and to train health professionals with a view which goes beyond the national borders and includes global changes. A resulting effect of this cooperation is that when students feel to be involved, they become operative and generate new project themselves (i.e. the project "Un ecografo a Wolisso" they carried on through a fund raising activity and a specific training for local health workers in Wolisso). Finally, students wanted to share their experiences with their mates, and therefore decided to create a blog in order to show how different medicine and life could be in a developing country: **www.educationglobalhealth.eu/blog**

# UNIVERSAL COVERAGE, FINANCIAL PROTECTION AND EQUITY

## POSTER PRESENTATIONS

**XV Giornate di Salute di Maputo**

- **Place of presentation**
  Maputo
- **Date of presentation**
  16th - 18th September 2015

MOZAMBIQUE

## MÉDICOS COM ÁFRICA CUAMM

# AMPLIAÇÃO DOS SERVIÇOS DE SAÚDE PARA JOVENS E ADOLESCENTES NA CIDADE DA BEIRA - MOÇAMBIQUE


> **ALEXANDRA GEORGE**, MÉDICOS COM ÁFRICA CUAMM
> **ALESSANDRO CASSINI**, MÉDICOS COM ÁFRICA CUAM
> **ARTURO SILVA**, MÉDICOS COM ÁFRICA CUAMM
> **GIOVANNI PUTOTO**, MÉDICOS COM ÁFRICA CUAMM
> **GUIDO MARINGUINI**, MÉDICOS COM ÁFRICA CUAMM


### INTRODUÇÃO

Em Moçambique, jovens de 10 a 24 anos representam 32% da população (52% raparigas), 34% vivem nas áreas urbanas. Deste grupo, 40% das raparigas não têm acesso a educação; 40% das raparigas de 15 a 19 anos tiveram pelo menos uma gravidez (INSIDA, 2009). O uso de contraceptivos em adolescentes de 15 a 19 anos é de 5,9% (DHS, 2011).
Os SAAJs (Serviço Amigo do Adolescente e Jovem) são serviços integrados e especializados para a saúde dos jovens adolescentes, com o objectivo de melhorar a educação, acesso e cuidados de saúde ao AJ. Abrange: saúde sexual reprodutiva, nutrição, higiene/saneamento do meio e saúde mental.
Realizamos uma avaliação independente do SAAJ e seu impacto na saúde dos jovens na Beira, avaliando os resultados de impacto.

### METODOLOGIA

Feita uma revisão e avaliação através de um estudo retrospectivo de dados estatísticos dos SAAJs em 2011 e 2013. Realizada uma análise comparativa aos dados estatísticos a fim de descrever, avaliar e analisar o progresso e qualidade dos serviços prestados ao AJ.

### RESULTADOS

Em 2013 duplicou o numero de jovens que frequentam SAAJ, e triplicou a testagem HIV, enquanto a positividade diminuiu. A maioria das consultas está relacionada com educação para prevenção do HIV/SIDA; aumentou o número de raparigas que procuram contracepção em 2013, procurando mais preservativos. No entanto, 50% das jovens que frequentam SAAJ são em consultas pré e pós parto.
Os jovens entre 10-14 anos são as que menos procuram SAAJ.

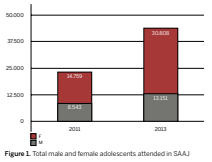


**Figure 1.** Total male and female adolescents attended in SAAJ

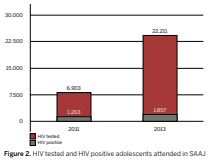


**Figure 2.** HIV tested and HIV positive adolescents attended in SAAJ

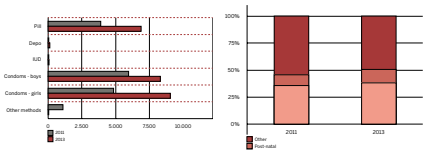


**Figure 3.** Contraception methods distributed to adolescents by SAAJ




**Figure 4.** Pre- and Post-natal are the majority of consultations

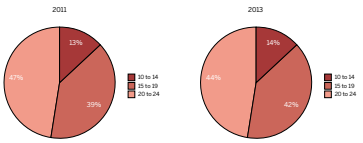


**Figure 5.** Classification by age of adolescents attending SAAJ

### CONCLUSÕES

Observou-se áreas de melhoria em termos de qualidade e comunicação sistemática; identificação dos resultados mensuráveis que avaliam o impacto dos SAAJs.
Os adolescentes têm necessidades específicas de saúde, mas estão muitas vezes entre os menos servidos de serviços de saúde; as intervenções devem ter uma abordagem estratégica, integrada e sistemática, para facilitar o acesso aos SAAJs, activando espaços independentes e humanizados; assegurando a privacidade e respeito pelo AJ com profissionais de saúde dedicados e treinados para o trabalho com os jovens.
Apesar das melhorias feitas, é preciso desenvolver estratégias para reforçar a prevenção da gravidez precoce e envolvimento de grupos etários mais jovens a nível comunitário e escolar.

MEDICI CON L'AFRICA CUAMM
Doctors with Africa

XV JORNADAS DE SAÚDE

Médicos com África CUAMM é uma organização que promove a saúde da população africana, trabalhando para as comunidades mais carentes, que são as mais invisíveis à maioria.

**XV Giornate di Salute di Maputo**

- **Place of presentation**
  Maputo
- **Date of presentation**
  16th - 18th September 2015

MOZAMBIQUE

## MÉDICOS COM ÁFRICA CUAMM

# EQUIDADE NA UTILIZAÇÃO DOS SERVIÇOS DE SAÚDE MATERNA NA BEIRA: UMA OPORTUNIDADE PARA MAXIMIZAR A PREVENÇÃO E O TARV


> **WILUNDA CALISTUS**, MÉDICOS COM ÁFRICA CUAMM ITÁLIA
> **G. PUTOTO**, MÉDICOS COM ÁFRICA CUAMM ITÁLIA
> **L. BRUMANA**, UNICEF MOÇAMBIQUE
> **D. MAHOTAS**, UNICEF MOÇAMBIQUE
> **C. FARNELA**, SDSMAS
> **M. MELO**, MÉDICOS COM ÁFRICA CUAMM BEIRA (MOÇAMBIQUE)
> **M. ROMANELLI**, MÉDICOS COM ÁFRICA CUAMM BEIRA (MOÇAMBIQUE)
> **F. RUSALEN**, MÉDICOS COM ÁFRICA CUAMM BEIRA (MOÇAMBIQUE)
> **ARTURO SILVA**, MÉDICOS COM ÁFRICA CUAMM BEIRA (MOÇAMBIQUE)


## INTRODUÇÃO

Sistemas de saúde fortes são essenciais para os programas equitativos e sustentáveis relacionados ao HIV/SIDA. A acessibilidade universal é um requisito chave para a Equidade. Isto é importante em áreas urbanas em países de baixa renda, onde há um crescimento da pobreza. Na Beira, apenas 34% das crianças seropositivas estão em TARV. A Maternidade é ponto crítico de entrada para mães e crianças aos serviços relacionados com prevenção e tratamento do HIV/SIDA. Este estudo foi realizado para desenvolver e aplicar uma ferramenta para medir a equidade na utilização dos serviços de assistência ao parto e avaliar a disponibilidade dos serviços de HIV/SIDA num cenário urbano.

## METODOLOGIA

A população de referência da amostra, estatisticamente significativa, foi todas as mulheres grávidas atendidas nas 11 Maternidades (CPN) da Beira durante 3 meses. Foi realizado a análise factorial das variáveis de bem-estar e as mulheres foram classificadas em quintis de riqueza e cruzadas com seis variantes (energia eléctrica, piso, telhado, combustível para cozinhar, telefone celular e relógio). As variáveis foram atribuídas pontuações cuja validade e confiabilidade foram avaliadas com referência ao índice de riqueza IDS (Inquérito Demográfico e de Saúde-2011). Foi utilizado um questionário para colectar a disponibilidade dos serviços de HIV/SIDA, suprimentos e medicamentos nas 11 maternidades.

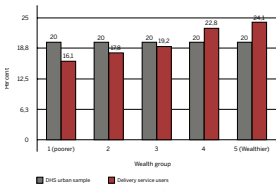


**Figure 1.** Distribution of women in Mozambique DHS urban sample and those utilizing delivery services in Beira by wealth group (p=0.420).

| Characteristics | | DHS urban sample n (%) | Delivery service users n | F test P value* |
|---|---|---|---|---|
| **Socio-demographic** | | | (%) | |
| **Age** | <20 | 134 (6.7) | 318 (22.5) | <0.001 |
| | 20-29 | 801 (40.3) | 800 (56.7) | |
| | 30-39 | 661 (33.3) | 257 (18.2) | |
| | >39 | 391 (19.7) | 37 (2.6) | |
| **Educational background** | No education | 230 (11.6) | 92 (6.5) | <0.001 |
| | Incomplete primary | 843 (42.4) | 297 (20.9) | |
| | Complete primary | 254 (12.8) | 227 (16.0) | |
| | Incomplete secondary | 486 (24.4) | 646 (45.4) | |
| | Complete secondary/higher | 175 (8.8) | 161 (11.3) | |
| **Proxy wealth variables** | | | | |
| **Has electricity** | | 1387 (69.8) | 1080 (75.9) | 0.145 |
| **Main floor material** | Earth/sand/dung | 471 (33.7) | 269 (18.9) | 0.189 |
| | Cement/tiles/carpet | 1517 (76.3) | 1154 (81.1) | |
| **Main cooking fuel** | Wood/straw/grass | 707 (35.6) | 444 (31.2) | 0.507 |
| | Coal/charcoal | 950 (47.8) | 748 (52.6) | |
| | Electricity/gas | 331 (16.6) | 231 (16.2) | |
| **Main roof material** | None/thatch/palm/polythene | 245 (12.3) | 146 (10.3) | 0.562 |
| | Iron/tiles/cement/lusalite | 1742 (877) | 1277 (89.7) | |
| **Has a cellphone** | | 1741 (876) | 1270 (89.2) | 0.490 |
| **Has a watch** | | 523 (26.3) | 513 (36.1) | 0.109 |
| **Total** | | 1987 | 1423 | |
| **Delivery service users: n=1412 for age; DHS sample: n=1988 for cellphone and floor.** | | | | |

**Table 1.** Characteristics of women in the Mozambique DHS urban sample and those utilizing delivery services in Beira

## RESULTADOS

A ferramenta da equidade foi válida e confiável. Participaram 1423 mulheres. Entre os usuários dos serviços, 16.1%, 17.8%, 19.2%, 22.8% e 24.1% pertencem a 1, 2, 3, 4 e 5 quintis de riqueza respectivamente (1 mais pobre, 5 mais rico) (Figura 1). O distribuição não foi significativamente diferente comparado com os dados de IDS (p=0.420). Não existe diferença de estado de riqueza entre as mulheres atendidas no HCB e USs (p=0,272) (Tabella 1). Cobertura de parto institucional foi de 97,9%. Todos os serviços realizavam teste HIV e TARV. Os ARV combinados para mães e recém-nascidos estavam em falta em 4 USs.

## CONCLUSÕES

O estudo mostra que os ricos usam o serviço público em vez do privado (indicação de qualidade). E também os pobres utilizam o serviço, o que significa que o acesso ao parto institucional na Beira é praticamente universal e equitativa. Essas duas propriedades do sistema de saúde são uma excelente oportunidade para maximizar a prevenção e tratamento do HIV/SIDA para mães e crianças. A escassez de drogas nas USs pode resultar em oportunidades perdidas e ameaçam a qualidade do atendimento.


**Palavras-chave**
Saúde materno infantil, Parto Institucional, HIV/SIDA.


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# Avaliação da qualidade dos cuidados de saúde nas crianças com malnutrição na Beira


## Authores

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## Introdução

A qualidade dos cuidados de saudé um problema global tanto em Países desenvolvidos como naqueles com recursos limitados tanto em cuidados primários como hospitalares tanto em doenças agudas como crónicas.

## Metodologia

Ferramenta de avaliação da Organizacao Mondial de Saude (adaptada) com objectivos de Avaliação da qualidade dos cuidados de saúde, fortalecer a implementação das línhas guias nacionais, consciencializar nos problemas, capacitar, providenciar soluções práticas e mudanças de atitude, introduzir o conceito de aperfeiçoamento de qualidade e promover motivação para a mudança no Hospital Central da Beira e nos Centros do Saude da Cidade da Beira.

## Resultados

A pesquisa mostrou alguns pontos de forças: centros de saúde recentemente reabilitados, pessoal motivado, existenca de uma linha guia nacional clara e completa, acesso gratuito aos cuidados de saúde, formacao de um grupo de activistas que ajudam na identificação e manejo dos casos. Apesar destes, os problemas comunes rescontrados foram: clinicos (falta de pessoal e pessoal qualificado, falta de aderenca as linhas guias existentes, falta de um sistema de triage para emergencias. Falta de conhecimento sobre as infeccioes), de equipamento e medicamentos e structural.

## Conclusões

O resultados mostram que as sugestões tem de ser a nivel de estruturas, de equipamentos, de staff e comunitario para a melhoria dos cuidados e para promover uma sensibilizacao sobre o problema da qualidade dos cuidados da saude na criança malnutrida.


**Palavras chave: Cuidados de saude, criança, malnutriçao, paises com recursos limitados**

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