

# Evaluation of the ambulance service for obstetric emergencies in the district of Pujehun, Sierra Leone.

*Cost-effectiveness analysis.*

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**Evaluation of the ambulance service for obstetric emergencies in the district of Pujehun, Sierra Leone: a cost-effectiveness analysis.**

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# Summary

The main aim of «Evaluation of the ambulance service for obstetric emergencies in the district of Pujehun, Sierra Leone: a cost-effectiveness analysis.» is to provide a cost-effectiveness analysis of the ambulance service implemented in Sierra Leone in the south district of Pujehun. The analysis investigates the role of the service in reducing the maternal and neonatal mortality; moreover, the service is evaluated considering only the referrals for obstetric emergencies. The country's profile is highly relevant to understand the final results of this cost-effective analysis. Sierra Leone tops the charts with the highest neonatal mortality rate and the lowest life expectancy at birth; furthermore, the district of Pujehun faces geographical barriers that pose challenges in the accessibility and successful implementation of a transportation system, including ambulance service. Many roads are not asphalted moreover they are interrupted with rivers, dense forests and flooded with water during the rainy season. Gas stations are scarce therefore refueling location should be planned ahead. All these factors pose serious challenges in the success of the ambulance service. The role of the ambulance service is to facilitate the referrals from the healthcare units spread in the district to the main hospital of Pujehun. The method of the cost-effective consists of two aspects: the costs and the effects. Regarding the costs, data on the total expenses of the service were collected; these included running costs for the ambulances, such as fuel and maintenance, for the communication system, for example mobile phones, and for the health assistance of the cases referred to the main hospital. For the effects, the criteria used to measure the impact of the ambulance service were clinical evaluations of the effectiveness of management of the cases referred, based on judgments of physicians who had several years of experience in Sierra Leone or in Africa in general. The final measuring unit to assess the cost-effectiveness of the intervention is the cost per life years gained in US Dollars. Finally, the final outcome is compared with the three threshold of effectiveness from the WHO and the ambulance service proves to be cost-effective.



# Preface

This dissertation was independently written by the author with the supervision of the Professor Rottingen assigned by the University of Oslo; therefore, the author of this dissertation is the only responsible entity for the data analyzed and the information reported in this paper.

The topic of this dissertation is inspired by previous studies conducted by two Non Governmental Organization one French, Medecins sans Frontieres, and one Italian, Medici con l'Africa CUAMM. Moreover, the framework for the drafting/writing and the development of the structure for the analysis were modelled similarly to these documents.

The concept of the study was established by the Italian NGO CUAMM during monitoring the development of their interventions in Sierra Leone begun years ago. The first aim was to monitor the project to understand the limitations and the needs; however, an additional aim was to demonstrate to the local government and to other NGOs working in the same field the results given by the implementation of the ambulance referral system.

Therefore, consistent updating and collection of new data is ongoing in CUAMM. The author collaborated with CUAMM through an internship which was conducted in the NGO's headquarter in Padova (Italy) from January to April 2016. Acknowledgement and recognition for the highly cooperative Italian and local team working in Sierra Leone and in particular those operating in the district of Pujehun.

The data used for assessing the effectiveness of the intervention were based on medical consultations of physicians working in the hospital of Pujehun that managed the cases; In addition to an expert opinion of a physician with several years of experience of working in the field in African countries.

Data concerning costs were collected by both Italian teams operating in Padova as well as Sierra Leone allowing more transparent and reliable data.

The authorization for the use and the publication of the data in this dissertation is given by the Italian NGO Medici con l'Africa – CUAMM.





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# Introduction

The Millennium Development goal of reducing child mortality by 2015 was not achieved by many Sub-Saharan African countries (Byass P, 2015) where 60% of the deaths are infants (Lambon-Quayefio MP, 2014). Delivery is a critical moment for both the mother and the child. Each year an astonishing two million neonatal deaths are attributed to complications during birth. This burden is mainly carried by the poorest countries (Joy E. Lawn, 2009). In low-income countries almost half of fetal deaths happen during or around delivery time and approximately three quarters of neonatal deaths occur within the first days after birth (S Kuruvilla, 2014). Therefore, evidence-based interventions are urgently required to reduce ante, intra and post-partum deaths. Many organizations, private and public, are working on the field to improve the situation and Medici con l’Africa CUAMM is one of them.

Medici con l’Africa CUAMM, or in English Doctors with Africa CUAMM is the oldest officially recognized Italian Non-Government Organization. CUAMM was founded in 1950 in Padova, by the Professor Antonio Canova who envisioned the core value that inspired the organization: “Freedom. This has always been our guiding principle since enduring beliefs can only be performed and young people can only achieve their ideals in a climate of freedom” (Medici con l’Africa CUAMM, 2014). During the last 66 years the NGO followed the principle that “Health is a right, fighting to respect it is a duty” and the fact that all the NGO’s activities are carried on a non-profit basis, makes the values of solidarity, justice and peace in the core of its mission and contributes to the process of growth and freedom of all human beings, especially the poorest and neediest. CUAMM is currently working in 7 African Countries; South Sudan, Ethiopia, Uganda, Tanzania, Mozambique, Angola and Sierra Leone. It is involved in many projects with the aim of promoting and safeguarding the population’s health and strengthening African health systems. CUAMM is interested in capacity building, research and diffusion of scientific knowledge to guarantee universal fulfillment of the fundamental human right to health. Moreover, the priority setting is based on long-term healthcare cooperation projects and training and re-training offered to the human resources both in Italy and in Africa.

In February 2012 CUAMM established its last branch in the South district of Pujehun , Sierra Leone. In May 2014 a devastating Ebola epidemic outbreak occurred and spread all over the country and extended to the surrounding countries; the confirmed cases updated at the 27<sup>th</sup> of

March of 2016 are up to 14.124 and of these 3.956 were fatal cases (World Health Organization, 2016). Sierra Leone was declared Ebola-free on the 7<sup>th</sup> of November of 2015 when 42 days passed since the last case of Ebola was diagnosed (World Health Organization, 2016); the Italian NGO remained operating on site during the whole outbreak period and until today. CUAMM has actively been working to support the health system providing continuous mother and child healthcare services.

In 2010 the local government launched the program “Free Healthcare” aimed at reinforcing the peripheral healthcare in the district of Pujehun which had the most vulnerable groups: pregnant women and children younger than 5 years old (CUAMM M. C., 2015). CUAMM has been receiving support from its partner the UNICEF in addition to the Italian Ministry of Foreign Affairs, the International Cooperation, the Italian Catholic Church (CEI – Chiesa Cattolica Italiana) and private donors. The reinforcement of the health services is composed of a continuous training for the local sanitary personnel, both for the personnel in the peripheral health units and in the main hospital of Pujehun. This training is mostly focused on reproductive health. In addition the Italian team works side by side to the local team in six peripheral health centers to improve the quality of the services for obstetric and neonatal emergencies. In January 2015, when the Ebola outbreak was slowly decreasing, ‘Free Healthcare’ restarted vigorously with strong enthusiasm of CUAMM and their innovative idea: the integration of a referral system with the use of the ambulance.

Evidence-based field examinations made the choice of structuring and implementing an ambulance service referral system very strategic in the district of Pujehun particularly in an effort to reduce the maternal and neonatal mortality. Many strategically located healthcare facilities are spread out in the district of; however, there is a massive lack of skilled medical staff and the high quality equipment. Moreover accessibility poses a vital obstacle due to the lack of transportation, both from the villages to the closer health centers and from the health centers to the main hospital of Pujehun.

# General Background

The urging question arises; what is the reason that causes the maternal mortality rate to be 100 times higher in low-income countries than in high-income countries (JointCommittee, 2013). Maternal death is defined by the International Classification of Diseases (ICD)-10 as *“the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes”*. While the maternal mortality rate is *“the number of maternal deaths in a population that occur during a given year per 100,000 live births”* (Bale JR, 2003). The likelihood to die from pregnancy is 97 times higher in developing countries than in developed countries (GiveWell, 2009) and more than half of these maternal deaths occur in Africa (Hill et al., 2001) (S Kuruvilla, 2014). The stillbirth and the neonatal mortality rate, defined respectively as *“the number of stillbirths per every 1,000 live births and stillbirths”* (CBS, 2012) and as *“the number of neonates dying before reaching 28 days of age, per 1,000 live births in a given year”* (The World Bank, 2016), are often 10 times higher in low-income countries than high income countries (JointCommittee, 2013) (World Health Organization, 2016).

The reasons of these disparities are many; however, a general explanation is that the interventions proposed to reduce the maternal, fetal and neonatal mortality were widely adopted in high-income countries but not enough in low-income countries (JointCommittee, 2013). Furthermore, it is important to shed light on the fact that the mortality causes and the interventions that reduce all the three mortality rates are often similar and sometimes even the same (JointCommittee, 2013) (S Kuruvilla, 2014) (Bale JR, 2003). The major medical causes of death for mothers are; hemorrhage, hypertensive diseases and maternal infections. While for fetuses and newborns some of the conditions that cause death are strongly linked with the mothers' conditions and preventable by treating the mothers, and for neonates important mortality causes are infections, asphyxia or prematurity. Interventions to reduce these deaths are well known and have been implemented with positive results in all high-income countries; most of the deaths attributed to pregnancy in developing countries could be prevented and averted through simple interventions. It is crucial to know the causes from which mothers, fetuses and newborns die and the time of the death (JointCommittee, 2013) : all mothers and neonates should have immediate access to interventions that reduce the risks of death, mostly

hospital based interventions (Julia Hussein, 2012) (Andrea B Pembe, 2010) (JointCommittee, 2013).

Despite the known fact that the most useful and successful strategy to reduce the mortality rate is rapid access to tertiary health facilities, yet three types of delay often occur and are the reasons for increasing the likelihood of the deaths (Bale JR, 2003) (CUAMM, 2016). First the delay in seeking care; due to the absence of information which makes people scared and hindered by the idea of costs associated with the health assistance. Additionally, the lack of faith in the medical services offered and reliance on the traditional medicine instead. Second form of delay is due to accessibility. This kind of delay is well documented and it is mostly related to geographical barriers, lack of communications systems, few and often unaffordable transportations, suboptimal distribution of health facilities, and scarce management of the health services from the decision makers. (Julia Hussein, 2012) Third is the delay in receiving care or the delay of the health personnel in recognizing an emergency and promptly intervening once the mother arrives to the health facility.

The deaths due to these delays can be prevented through many interventions and strategies. These are well known and worldwide adopted, and goes from antenatal care to postnatal care, intervention involving behavioral change, prevention, recognition and treatment of the major causes of deaths such as properly managing various diseases such as hypertensive diseases, anemia and malaria. Nutritional interventions, and finally training and presence of skilled attendance at childbirth (JointCommittee, 2013)(Bale JR, 2003).

Despite these approaches, it is essential to focus on interventions that aim to improve pregnancy outcomes and systems based on a multisector approach (JointCommittee, 2013)(S Kuruvilla, 2014). Therefore, as previously mentioned, the most important factor would be to find a system that enables rapid access to care and especially secondary or tertiary healthcare facilities which possess the skilled medical staff.

One of the strategies to reduce the second type of delay is the use of a motherhood referral system, which brings the third or second level of health assistance closer to people enhancing the access to health care. However, this method is difficult to evaluate due to limited available resources in the health units at the primary level of care; in fact, more access implies highly complicated emergencies the third or second level hospitals have to deal with most of the time not adequate equipment and medical staff (Andrea B Pembe, 2010). Additionally, it is

impossible to disentangle the effects of the referral system itself with other interventions that improve care managing the other types of delay (Julia Hussein, 2012) and it is therefore difficult to attribute only to the referral system the merit of the possible success. Moreover, evidence of the strong connection between the first and second types of delay. One of the major limitations to the positive results of the referral system is the low compliance to the referral advice; this is mostly related to the fact that women have first to understand and acknowledge that they need medical care and then have the permission from their husbands before seeking care (Unicef, 2009). Additional limitations are linked to the scarcity, the high cost of transportation, and the perception of the quality of care received at the hospitals (Andrea B Pembe, 2010). Therefore, improving the interactions between the frontline workers and mothers is crucial to increase the effectiveness of the coverage (G L Darmstadt, 2013) through the inclusion of behavioral changing strategies, both at the community level, at home and in the primary health care facilities (G L Darmstadt, 2013).

## **Pujehun**

The surface of the entire district of Pujehun is 4.105 square kilometers and the number of inhabitants is 375.000. The main land consists of the larger area and it has 9 of the 12 chiefdoms, the inhabitants of these areas are 265.000. The southern part of the district is divided from the main land by the Mano river, the area consists of one chiefdom and part of another and counts for 30.000 inhabitants. The Moa River flows on the east part of the district flows forming a natural barrier for the 80.000 inhabitants of the 2 chiefdoms that are separated from the main land, this geographical barrier is highly relevant in this analysis since it separates the main hospital of Pujehun from the rest of the territory which makes the communications, the transportations and any kind of connections more challenging. Ferryboats are essential to connect the chiefdoms on the other side of the two rivers to the main land. During the rainy season which runs every year from July to December, the situation becomes even more complicated. Roads are flooded and people live without electricity for an undefined number of days. There are 77 peripheral health units in the district and the main hospital of Pujehun is almost in the center of the territory. The buildings themselves are in acceptable conditions, however, the lack of equipment, antibiotics, and the

absence of skilled medical personnel drastically decrease the possibility of any kind of intervention. Only 8 of the 77 the peripheral health units have at least one skilled midwife.

The Italian NGO Medici con l'Africa CUAMM decided to invest in the referral system through three ways: communications, transport and information and governance.

The emergency contacts were widely advertised; the ambulance cars are reachable 24/24h they work 7/7 days. A skilled midwife is always present at the maternity call center in the main hospital of Pujehun, she answers the calls and helps in directing the operations by phone. All calls are free of charge due to a line call system among the peripheral health units, the ambulances and the main hospital. When there is no network, a problem that often arises in the district, the health facilities and ambulances are provided by satellite phone. Additionally, in case of absence of electricity all the centers have solar chargers that supply the phone batteries.

Three ambulances are operating in the district; they are well equipped and operated by a driver, an assistant and most of the time, also skilled nurse intervenes when needed. All of them receive food allowance and financial incentives for every referral. The budget for the transportation include the insurances for the cars, the fuel and the maintenance. The fact that the roads are not in good conditions, especially during the rainy season, the costs of maintenance tend to be high.

The staff of the peripheral units is invited to participate in charge meetings where they are trained to deal with situations of emergency, they learn how to use the referral form, how to fill it at the moment of transfer and where they receive feedbacks from the hospital on the forms. Many entities such as the District Health Management Team (DHMT), the District Council and the Paramount Chiefs, in collaboration with the staff of the peripheral health units continuously inform the village communities about ambulance service and aim to involve and solicit the communities to actively use the service. The service being free of charge is strongly emphasized; in fact, most of the time people are reluctant to call because they believe they cannot afford the transport leading to a delay in seeking the care. A monthly Health Review Meeting takes place in which all district stakeholders and the constitution by DHMT, hospital, Council and CUAMM congregate. Discussions on the district situations, the development and management of the services are carried out during the meeting.



To overcome the barriers of the Mano and Moa rivers the ambulance is located in Jendema, a peripheral health unit on the other side of the Moa river, and to connect the peripheral units located on the side of the Mano river using boats. The ambulance in Jendema reaches the peripheral units calling for emergencies and meets at the ferryboat point along the Moa river with the ambulance that arrived from the main hospital of Pujehun. The patient is transported to the ambulance arriving from Pujehun and the one from the Jendema returns back. The health units in the Mano river areas use the boats to reach the health units closer to the main land; where the ambulance which arrived from Pujehun is ready to leave. The rest of the main land is covered by the two ambulances based in Pujehun.

#### *Date Pujehun*

In 2015, the expected number of pregnancies was 16.537 while the expected major direct obstetric complications (MDOC) was 2.480, 15% of the total number of pregnancies. A comparison between the hospital activities of Pujehun in 2014 and at the end of 2015, clearly indicates a drastic improvement in all the medical interventions: the admission in maternity wards increased by 80%, the total deliveries by 86% and the MDOC treated in the maternity by 245%. The improvement concerned also the obstetric referral with an increment of 251% and of 499% for the pediatric referral. (CUAMM, 2016)

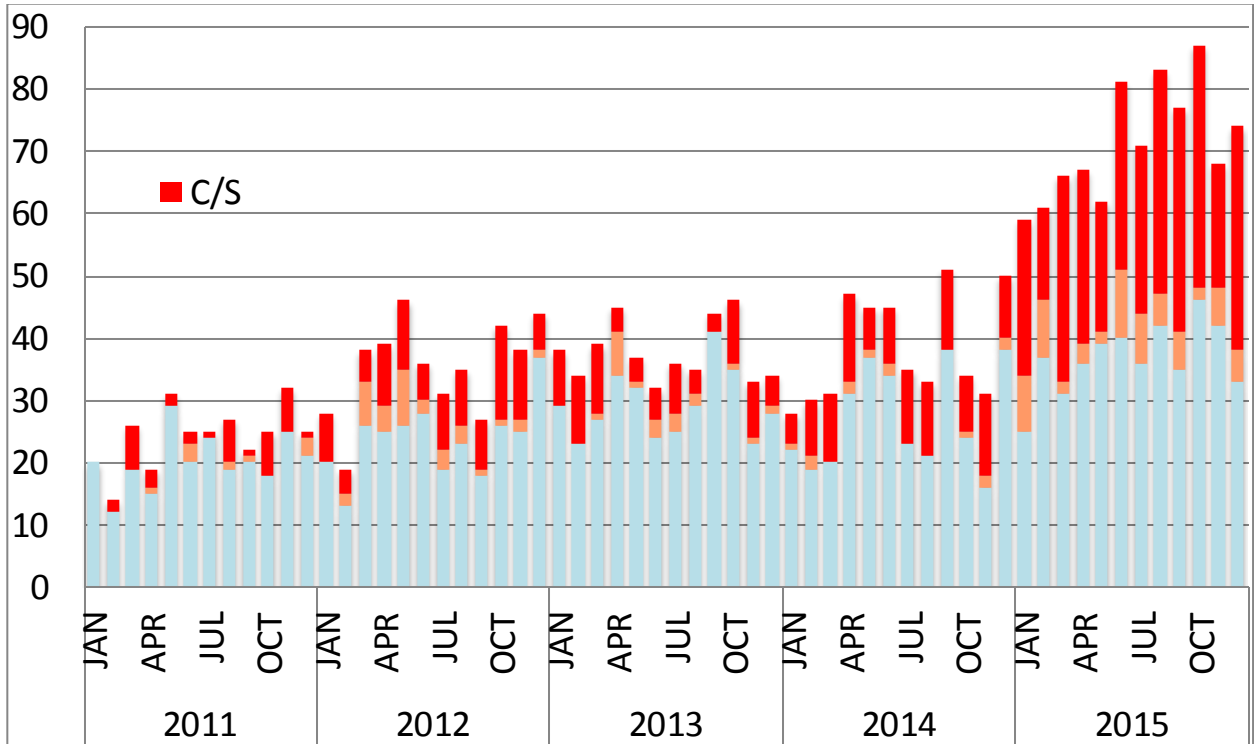


Figure 1 Pujehun hospital institutional deliveries 2011 – 2015 (CUAMM M. c., 2016)

The figure reports the rate of institutional deliveries that highly increased since the beginning of 2015 when the ambulance service started. Moreover, the boom was registered around June, this time coincides with the actual beginning of the work in Pujehun of the CUAMM. From January 2014 to December 2015 the rate of delivery at the PU hospital increased on average by 86 % furthermore the CS augmented on average by 203 % demonstrating the impact that the ambulance service had on the MDOC. Also concerning the direct obstetric mortality rate a drastic decrement by 17,02% in 2011, 2,75% in 2013 and 0,89% in 2015.

# Cost-effectiveness analysis

The management of the healthcare in low and middle income countries (LMIC) and the interventions needed are still an open debate. While the majority of the governments of high income countries (U.S. and Euro area) have widely invested in the healthcare sector, in some LMIC the average health expenses as a percentage of the total GDP is sometimes lower than the minimum to provide the very basic service (Xu Ke, 2011). For example, in the Sub-Saharan Africa areas the total health expenditure is about 5.7 per cent of the total GDP on health (The World Bank, 2015), far less than the 9.9 per cent spent by the OECD countries (Kinsella, 2012).

In settings with limited resources budget constraints necessitates the prioritization of potential interventions and their constant monitoring over time. Cost-effectiveness analysis (CEA) is a vital tool to monitor the intervention and to allow for further improvements.

In fact, the CEA helps to recognize ways to redirect resources, it guides from ineffective to effective interventions but also from less to more cost-effective interventions. The basic calculation for this process implies dividing the total cost of an intervention, expressed in monetary units, by the health gains measured in natural units, for example in life years gained (Jamison DT, 2006).

Therefore the choice of the units of measurement is crucial; in order to allow for comparison among different studies. Additionally, the most direct method is to compare interventions addressing the same issue and that differ only in the way of delivery. Furthermore, the better the aim of intervention in improving someone's health is clarified and detailed the more reliable is the comparison with contexts with similar characteristics and the better is the interpretation of the results. Similarly, the quality of the available evidence is decisive to access CEA; the most reliable evidence most of the time comes from study with randomized controls or systematic overviews (Jamison DT, 2006).

The decision-makers rely on the CEA for allocating resources and choosing the intervention to implement. To better guide the policy makers, CEA should be provided with an extensive report of the context of implementation; information regarding the prevalence and the burden of diseases, the existent coverage of the services and the overall capacity of the health system.

In fact, in presence of a low coverage of the health services it is simpler to choose and implement interventions considered cost-effective but, on the other hand, when the health system does not work appropriately, interventions that deeply rely on medical staff, adequate equipment or sophisticated data systems will unlikely be cost-effective (Jamison DT, 2006). Furthermore, the decision-makers should reflect on the trade-off between the health-related choices and the distribution consequences. In fact, when doing a CEA, the health gains are equally evaluated, however, it should be analyzed the distribution of these gains derived from the fact that it is possible that an intervention judged as cost-effective could generate more health improvements when the available resources are scarce in this case it will be considered even more cost-effective.

In conclusion, each choice is fundamental for the analysis and in order to study the development of the ambulance service and its impact, the decision to undertake a CEA is due to the fact that for this analysis it was not put a monetary value on health benefit but natural units. When comparing interventions that address the same health problems it is considered the most useful analysis as it reports the cost per unit of health effects aspect that other cost analyses do not consider (Glenda A. Stone, 2014).

## **Findings from the cost-effectiveness analysis**

The final result of the cost-effectiveness analysis is expressed as cost per life year gained due to the intervention which is 49 US Dollars without any discount and 74 US Dollars when the effects are discounted by 3 %. This outcome is the relation between the total costs of the services and the sum of life years gained by each referral considered undoubtedly effective. Furthermore, to evaluate the cost-effectiveness of the intervention, the cost per life years gained obtained was compared with three threshold of effectiveness from the WHO standards (World Health Organization, 1996). These consider the intervention to be very attractive when the cost per life years gained is below 30 US Dollars, attractive when below 150 US Dollars and acceptable when it remains below the GDP per capita of the nation of the analysis, therefore for the Sierra Leone 537 US Dollars. The cost per life years gained

discounted for the effects at 3% of 74 US Dollars indicates the intervention to be attractive because it is below 150 US Dollars.

The calculation of the costs includes the costs of the ambulances therefore costs of fuel consumed, insurances, maintenance, salaries for the personnel and relative incentives for referrals and materials, and costs of the communication system such as phones and relative SIM cards, phones credit, solar batteries and additional costs for committee and advertisement. After adding the costs of the health assistance in the hospital of Pujehun the total costs were equal to 68,689 US Dollars. Concerning the effects, the assessment is based on the sum of life years gained for the referred mothers and newborns. The total life years gained was 1,393 years and 926,5 years when discounted by 3 %. These count the 61 mothers and 18 newborns referred and treated at the hospital that where considered undoubtedly effective interventions.

Additionally, the sensitivity analysis conducted report firstly that by keeping the proportion of the undoubtedly effective cases constant and changing the total costs the intervention becomes very attractive (below 30 USD cut-off) at 27.795 US Dollars. Secondly, by holding the total costs constant and changing the proportion of undoubtedly effective cases, the interventions results to be very attractive (below 30 USD cut-off) when the percentage of the cases reaches 16 %. Lastly, when moving together the total costs and the total life years gained discounted at the rate of 3%, the most favorable results are achieved when the total costs are 30.000 US Dollar compared with 1.000 life years gained as well as when the total costs are 60.000 US Dollar and the life years gained 2.000.

Finally, a cost-effectiveness analysis was conducted when considering together the undoubtedly effective and possibly effective referrals. The sum of the two leads to the total live years gained of 5191,6 with a 3% discount rate while the total costs remain unchanged. Therefore, the cost per life years gained with 3 % discount obtained was 13 US Dollars and the intervention is considered very attractive because it is below the threshold of 30 US Dollars.

A sensitivity analysis for the changing in the costs similar to the previous was conducted for undoubtedly and possibly effective cases considered together. Holding the proportion of undoubtedly and possibly effective cases constant, the total costs in order to consider the intervention very attractive (below 30 USD cut-off) must be equal to 127.849 US Dollars.

# Conclusions

The geographical barriers and the delays at the community level to seek and reach care, are undoubtedly an important limit for the implementation of the ambulance service and for its results. These together with the scarce level of the health equipment and few skilled medical staff present, lead the characteristics of the district to hamper the successful implementation of the service.

However, despite the possible limitations of the analysis, the results have demonstrated that:

1. The ambulance service significantly increases the number of women with obstetric complications that have been referred to the main hospital of Pujehun.
2. The majority of these referrals follow correct medical indications leading to positive cure and healing.
3. The referrals improve mother and child survival with undoubtedly effectiveness in 27 per cent of the cases.
4. The cost per life year gained with 3% discount rate is equal to 70 US Dollars.
5. The service can be considered cost-effective.

Additional future action of monitoring is needed.

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# Appendix

## **Evaluation of the ambulance service for obstetric emergencies in the district of Pujehun, Sierra Leone: a cost-effectiveness analysis.**

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### Summary

#### OBJECTIVE

The aim of the analysis is to evaluate the cost-effectiveness of the ambulance system for obstetric emergencies implemented in January 2015 in the district of Pujehun in Sierra Leone. The service has the final goal to reduce the maternal mortality increasing the rate of institutional deliveries.

#### METHODS

A cost-effectiveness analysis with final outcome the cost per life year gained. The perspective of the study is from the healthcare system and it is a retrospective empirical study. The data were collected with the help of the team in loco; a group of expert physicians collaborated to evaluate the clinical data of the obstetric emergencies referred as not effective, possible effective and undoubtedly effective in accordance with established criteria. Only the cases where the referrals were considered as undoubtedly effective were included in the analyses. Three cut-offs were used to indicate whether the intervention was very attractive, attractive or acceptable. Three sensitivity analysis were conducted.

## RESULTS

During the 6 months of the study 455 patients were referred to the main hospital of Pujehun, of these 295 were obstetric emergencies. Among these emergencies, 61 mothers and 18 newborns referrals with medical follow up have been evaluated to be undoubtedly effective by the physicians. The intervention was considered cost-effective with a cost per life year gained of 74 US Dollar with 3% discount rate on the effects. With sensitivity analyses more robustness of the final results was given.

## CONCLUSIONS

Despite the difficulties met due to the natural barriers, the ambulance service can be considered cost-effective. Future and constant monitoring of the intervention is needed.

### **Introduction**

While on average in the world maternal and neonatal mortality is drastically decreasing and the life expectancy is rapidly increasing, in Sierra Leone the situation is only slowly changing. Sierra Leone is remaining the place in the world with the highest under five mortality, moving from 273 deaths per 1000 million live births in 1995 to 187 deaths in 2015 (UN, 2013). In 2013, Sierra Leone was ranked with the lowest life expectancy at birth, reporting 46 years old (WHO, 2016). Since 2008, before the outbreak of Ebola in 2014, a nationwide needs assessment for Emergency Obstetrics and Newborn Care (EmONC) was undertaken by the Sierra Leone Ministry of Health and Sanitation (MOHS) in collaboration with the Joint UN partners such as WHO, WFP, UNFPA and UNICEF. (MoHS, 2008) The aims are to identify the presence and the use of the EmONC services, the quality and the lacks of the system to delivery in order to monitor the situation and provide future interventions.

One of the major issues was the presence of numerous peripheral health facilities or units (PHU) spread in the country lacking equipment and skilled personnel. Additionally, all the PHU work as separate islands and are not connected to each other. The long distances between the villages and the health facilities added to the damaged roads and the costs of the public transport not affordable by most of the population, contribute to the delay in identifying the need to seek health care. These difficulties greatly contribute to increase maternal and neonatal mortality producing delay in reaching a better equipped health facility



floated and people mainly live in stilt houses or palafitte, houses made out of wood and raised on piles over water. In these areas the use of the ambulance is integrated with boats that reach the PHUs and arrive to the PHU in Borbobu Chiefdom of Panga Krim. There it will be an ambulance waiting to go to Pujehun hospital. The area separated by the Moa river is mainly the Chiefdom of Soro Gbema; there is located Jendema base of the ambulance operating for the area. The ambulance leaves Jendema and reaches the PHU in need; the personnel carry the patient and often also the midwife, and go to the point along the river where the ferryboat is. The ambulance crosses the river and the patient is moved on a second ambulance waiting on the other side and ready to go to Pujehun hospital. This “half way” service is provided especially during the rainy season when the use of the ferryboat is a must. During the dry season the ambulance can independently cross the river and reaches the PHUs. The rainy season mostly begins in June-July and ends in December. The period of the study exactly corresponds to the rainy season. An additional area covered by the ambulance service is the Chiefdom of Bum, part of the main land but located in out of the district Pujehun.

The major second level hospital is located almost in the center of the district in health units of Pujehun in the Chiefdom of Kpanga Kabonde. In the entire district of Pujehun there are 77 peripheral health units; these consist of 13 Community Health Centers (CHC) that are the biggest centers where skilled nurses or midwives or Clinical Health Officer (CHO) constantly operate; 5 of the CHC are EmONC where well prepared obstetrics work side by side to the CHO; 15 are smaller centers for adults and children called Community Health Post (CHP), while 49 are Maternal and Child Health Post (MCHP). In the MCHP are provided free of charge service of antenatal care and ambulatory visits; these are offered only to mothers and children younger than 5 years old. Each PHU is provided by telephones and SIM cards, and on each ambulance 1 mobile phone with SIM card and a satellite phone with SIM card is available. The total number of ambulance is three: two based at Pujehun hospital and one in the PHU of Jendema. At the call center in Pujehun hospital a skilled midwife is reachable through a mobile or a satellite phone both provided by SIM cards. During every referral on the ambulance work one driver, one assistant driver and one nurse; all the members receive a financial incentive for every call. The ambulance service is provided 24/24h for 7 days.

Therefore, depending on where the call is from, the referral system works in 2 ways:

Option one: the call is from the main land. Involved are the Chiefdoms in the main land, the areas of Mano river and the Chiefdom of Bum out of the district. The ambulance leaves PU

hospital and reaches the PHU in need. On the ambulance is constant one driver, one assistant driver and one nurse. At the PHU, the woman in need is carried on and the ambulance returns to PU hospital. Depending on the gravity of the situations, also the midwife of the PHU participate in the referral.

Option two: the call is from the area beyond the Moa river. Two are the ambulances involved in the operation. After the call, the ambulance from PU hospital and from the PHU in Jendema operate together. The ambulance in Jendema reaches first the PHU, carries the patient and moves to the Moa river. The ambulance in PU hospital arrives at the point along the Moa river where the service of ferryboat is provided and there the two ambulances meet. The patient is moved to the PU ambulance that promptly runs to the main hospital. The other ambulance returns to Jendema.

#### *Design and data collection*

The ambulance service started in January 2015; this study has a time horizon of 6 months, from the 1st of July to the 31st of December. The choice of the time horizon is linked with the difficulty in getting reliable data before July. Consequently, the cost-effectiveness analysis done is a retrospective analysis conducted at the beginning of the year after, January 2016. The study uses a healthcare perspective. The final outcome is expressed as the cost per life years gained, which has as the denominator the total costs and as the numerator the total life years gained. Data were collected through Skype meetings with the CUAMM staff in Pujehun and their detections in loco. To know the distances run by the ambulances during the service it was examined the call-books, these are registers that the drivers keep on the ambulance and where are written the kilometers covered in each travel. Additionally, medical and financial records were used. Finally, a literature review was done mainly to guide the collection of data regarding the costs and to be advised from other similar studies. Indeed, this cost-effective analysis takes as a guideline a previous analysis conducted on the same topic by Somigliana *et al* (Edgardo Somigliana, 2011). Similarly, it is also inspired by the work conducted by MSF in Burundi. (MSF, 2013)

Furthermore, the health effects reported were discounted by 3%. The reason behind this choice was to allow for a more accurate comparison of the final outcomes with similar studies; in fact, 3 % is considered by most the standard approach (Johan L. Severens, 2004).

Additional explanation regards the formula used to discount that aims to emphasize the low income setting as the final outcome would be qualified in DALYs, disability-adjusted life years. (Sassi, 2006)

### *Costs.*

From a healthcare perspective all the costs related to the service of ambulances have been included. These were divided into two categories; the costs of the ambulance and the costs of the health assistance. Among the costs of the ambulance are those exclusively linked to the transport; these are both the costs for the vehicles themselves, such as insurance, fuel and maintenance, and those related to the personnel, salaries and incentives for referrals. Among the transport' costs are included the costs for the communication system, such as mobile phones and credit system. The costs for the three vehicles consider 4 years of lifespan and the unit cost reported is the averages of the expenses for the three different ambulances. Additional assumptions on costs done mainly referred to the cars consumption and the lifespan of the communication devices. The costs of the health assistance are the costs for treating the women and newborns referred to the PU hospital. These mainly consist in surgery procedurals and in particular are caesarean section (CS), laparotomy, spontaneous standard delivery (SVD) and treatment of possible major complications such as eclampsia, placenta removal. Expert physicians with many years of experience in Africa estimated the costs of the health assistance for this specific context. The costs that were excluded from the analysis are all the costs that would have occurred also without the existence of the ambulance service. These include the costs of the uncomplicated procedures that could have been solved without surgery and simple procedures that could have been treated at the PHUs, the cases transferred with wrong clinical indications, the salaries for the nurses involved in the service that would have been provided despite the referral system, similarly the cost for the all personnel in the hospital. Additionally, it was not counted the boat services both for both rivers because most of the time free of charge.

### *Effects.*

The obstetric emergencies referred at the main hospital were clinically evaluated by two expert physicians. The evaluation was based on an essential question: would any other type of

transportation, different than the ambulance, have the same impact on the survival of the mothers and the newborns? When analyzing the referrals, three were the classifications given by the physicians: undoubtedly effective (UE), possibly effective (PE) and not effective (NE). In box 1 the classifications are better explained. In this work, the cases included in the calculation for the final outcome are only those considered undoubtedly effective. Moreover, the UE cases have been considered separately for the mothers and for the newborns. An additional analysis was conducted taking into consideration also the possibly effective. The benefits achieved from the ambulance service are presented as the life years gained for each case of UE separately for mothers and newborns. The life expectancy adopted is the estimation reported by the WHO equal to 46 years both for male and female. In order to calculate the life expectancy related to the different ages of the mothers, it was used the table for “the expectation of life at age” available at the WHO data site <http://apps.who.int/gho/data/view.main.61480?lang=en>. In the table are reported the average life expectancy at each age; the years of age are clustered in groups each containing four years, from 1 to 4, 5 to 9, 10 to 14, until 100+. The older the woman becomes the lower the her expectation the higher the life years gained when the intervention is undoubtedly effective. The formula to calculate the total life years gained is the following, 46 (average life expectancy) minus the expectation of life at the age of the mother (indicated in the table). For each case the same formula was adopted and the total life years gained is the sum of all cases.

**Box I : Clinical evaluation of the obstetric emergencies cases referred by the ambulance in Pujehun.**

- Undoubtedly effective cases – UE, when another type of transportation would have had for sure a fatal result on the survival of the mother and/or the newborn.
- Possible effective cases – PE, when another type of transportation could have had a negative or positive impact on the survival of the mother and/or the newborn. In this case it is not possible to exclude that the transport with the ambulance would have been effective, or not effective, for sure.
- Not effective cases – NE, when another type of transportation would have had for sure the same impact on the survival of the mother and/or the newborn that the ambulance had in the same situation.



### Cost-effectiveness

The costs per life years gained were assessed against three different thresholds. The intervention was considered acceptable when the cost per life years gained was less than 537 USD, which is the Sierra Leone GDP per capita in 2014 (TradingEconomics), attractive when less than 150 USD and very attractive when less than 30 USD. (World Health Organization, 1996) (Lubell Y, 2008).

The choice of the thresholds is due to their highly comparability with similar studies; in fact, they are considered as the standard thresholds and they are largely used in numerous researches. Consistent is the criteria behind these thresholds; it takes into consideration the extreme poverty conditions and the budgetary concerns of low and middle income countries. (Samuel D. Shillcutt, 2009)

### Results.

From July to December 455 referrals with ambulance have been registered. Among those, 295 were EmONC cases and these are the cases clinically evaluated. Table 1 reports the baseline characteristics of the women referred. In table 2 are listed the main clinical reasons for the referrals. In table 3 the locations of the referrals are reported. It results that almost 30% of the referrals were not from the mainland.

Among 295 EmONC cases, 61 (21%) referrals for mothers were clinically evaluated undoubtedly effective (UE) and 18 (6%) were the UE newborns' referrals. Considering the

**Table 1 Baseline characteristics.**

Characteristics (n =295)		
Age groups (years)	n	%
13 - 19 yrs	95	32%
20 - 29 yrs	99	33,6%
30 - 39 yrs	92	31,2%
> 40 yrs	7	2,4%
missing	2	0,7%
Mean age $\pm$ SD or n (%)		25,21 $\pm$ 7,21
Numbers of previous deliverie	n	%
1	106	35,9%
2 or 3	64	21,7%
4 or 5	50	16,9%
6 or 7	37	12,5%
8 or 9	21	7,1%
> 10	16	5,4%
missing	1	0,3%

**Table 2 Reasons for referral.**

Clinical findings for referral		
Reasons for referral	n	%
Prolonged/Obstructed Labour	146	49,5%
APH	37	12,5%
Severe Pre-Eclampsia/Eclampsia	33	11,2%
Abortion Complication	25	8,5%
PPH	22	7,5%
Post partum sepsi	12	4,1%
Ectopic pregnancy	12	4,1%
Rupture uterus	6	2,0%
IUFD	2	0,7%

APH = Antepartum hemorrhage; PPH = Post partum hemorrhage; IUFD = intrauterine fetal demise.

possible effective cases (PE), for the mothers and the newborns were respectively 99 and 143. Consequently, the evaluation of not effective cases (NE) reported 135 mothers and 134 newborns. In table 4 are listed the reasons for the referrals considering separately the UE, PE and NE cases In table 5 are reported the life years gained for the transfers UE, the possible life years gained for the PE and the life years not gained for the NE; these have been calculated with and without the discount rate of 3%.

**Table 3 UE, PE, NE cases and reasons for referrals.**

Clinical conditions of each mother referred.				
Reasons for referral	n Total	n UE (%)	n PE (%)	n NE (%)
Prolonged/Obstructed Labour	146	6 (4%)	60 (41%)	80 (55%)
APH	37	22 (59%)	11 (30%)	4 (11%)
Severe Pre-Eclampsia/Eclampsia	33	11(33%)	11(33%)	11(33%)
Abortion Complication	25	1 (4%)	8 (31%)	16 (64%)
PPH	22	3 (14%)	8 (36%)	11 (50%)
Post partum sepsi	12	0 (0%)	1 (8%)	11 (92%)
Ectopic pregnancy	12	12 (100%)	0 (0%)	0 (0%)
Rupture uterus	6	6 (100%)	0 (0%)	0 (0%)
IUFD	2	0 (0%)	0 (0%)	2 (100%)
<b>Total</b>	<b>295</b>	<b>61 (20,28%)</b>	<b>99 (33,56%)</b>	<b>135(45,76%)</b>

**Table 4 Life years gained for UE, PE, NE cases.**

		n	LYs	LYs 3%	Tot n	Tot LYs	Tot LYs 3%
UE	Mothers	61	564,7	477,45	79	1392,7	926,5
	Newborns	18	828	449,05			
PE	Mothers	99	828,9	697,58	242	7406,9	4265,06
	Newborns	143	6578	3567,48			
NE	Mothers	135	1008,8	865,85	269	7172,8	4208,8
	Newborns	134	6164	3342,95			

Formula used to discount =  $(1 - e^{-r \cdot LYsXi}) / r$ , where e is the function of exponential, r corresponds to 3% discount rate and LYsXi are the life years gained of each mother. (Sassi2006)

For the calculation of the costs, all the 455 referrals of the 6 months were taken into account. The expenses for the ambulance services are reported in table 6. The total costs are the sum of the costs for the ambulance service for the 6 months, that were 59.999 \$, and the costs of the health treatments for the 61 UE women cases registered. These last have been estimated to be 8.690 \$. Therefore, the total costs were 68.689 \$.

When the only the UE cases are considered, the cost per life years gained is 49 US Dollar. Discounting the life years gained with the standard 3% rate, the total life years decreases from 1.393 to 927 and the cost per life years gained increases up to 74 US dollars. The final result is consistent and the intervention is considered attractive.

As expected, the most favorable outcome for the intervention is accomplished when considering together the PE and UE cases. The reason for considering concurrently the UE and PE is to allow for possible errors during the evaluation of the undoubtedly effective cases. In fact, in a retrospective study it might happen that some of UE cases are wrongly considered as PE. Including both UE and PE this risk is minimized. The two expert physicians evaluated that 33,6% of the total number of possible effective cases were mothers and 48,5% were newborns. The total life years gained with 3 % discount reaches 5192 years leading the cost per life years gained to 13 US Dollar. Therefore, when considering both the PE and UE cases, the intervention is far below the 30 US Dollar and it can be considered very attractive.

**Table 5 Total costs for the ambulance service.**

Expenses	Cost per unit (\$)	Costs for the study period (6 months)
<b>Transport</b>		
Vehicles (Toyota Land Cruiser)* (n=3)	9653	21.718
Vehicles tax and insurance	2.088 (per year)	1.044
Vehicles repair and maintenance	11.721 (per year)	11.721
Fuel †	-	6.233
Drivers - gross salaries (n=3)	1751 (per months)	2.627
Incentives/referral (n=455)	22500 (per referral)	6.523
Accommodation for drivers	989	989
IPC material ‡	-	190
<b>Communication system</b>		
Phones † & sim cards	107	1.531
Call center operator	7 (per days)	1.064
Air-time	-	2.703
CUG System ‡ (n=81)	6	116
Solar batteries † (n=77)	50	1.930
Maternal referral committee ‡ (n=10)	10 (per participant)	313
Advertisement costs	-	1.298
<b>Total</b>	<b>n.a.</b>	<b>59.999</b>

All the costs are expressed in US Dollars. The exchange rate applied is 1USD = 4315,77SLL.

\*Calculation done base on 4 years lifespan and on the use of the car; 1 ambulance has been used since January (price divided by 4), 2 ambulance since July (prices divided by 8). †50.775 is the estimation of km considering those reported in the log-books and the distances of the PHUs. The car consumption is 5 lt/km while the price of the fuel during those months was 1lt = 4.167 SLL. ‡It includes earphones, boots, gloves and other ambulance materials such as log book, pens, jack, axe, roop, PA system, jerrycan. †Phones are mobile phones for 3 ambulance and call center and 77 telephone for PHUs. Calculation based on 1 year duration. ‡CUG = closed user group, system operating for all 81 phones. †Calculation done considering a duration of 2 years. ‡ Calculation done considering a duration of 2 years. ‡Monthly meeting attended by on average of 10 participants receiving an incentive for coming. n.a. : not applicable.

Three sensitivity analyses were conducted. First, modifying the total costs and holding constant the UE cases; second, changing the proportion of the mothers UE and holding constant the total costs; third, moving together both total costs and proportion of UE cases.

For the first analysis, varying the total costs, the cost-effectiveness changes and the service becomes very attractive (below 30 USD cut-off) when the costs decrease to 27.795 US Dollar or by 40,89%. The intervention can be considered attractive until the costs reach 138.975 US Dollar or decrement of 70,29% (below 150 USD cut-off), and acceptable up to 497.531 US Dollar (below 537 USD cut-off) that corresponds to an increment of 428,84%.

Secondly, changing the proportion of the UE cases for the mothers, the intervention keeps very attractive up to 16,87 %, attractive until the threshold of 3,37 % and acceptable when the proportion of UE is 0,94 %. With a multivariate sensitivity analysis the cut-off of 30 US Dollars is reached when the total costs are 30.000 and the total life years gained with 3 % discount are equal to 1.000. Similarly, the very attractive results is achieved when the total costs increases to 60.000 while the total life years gained discount at 3% equal 2.000. Therefore, the proportion costs-effects results in 3:1.

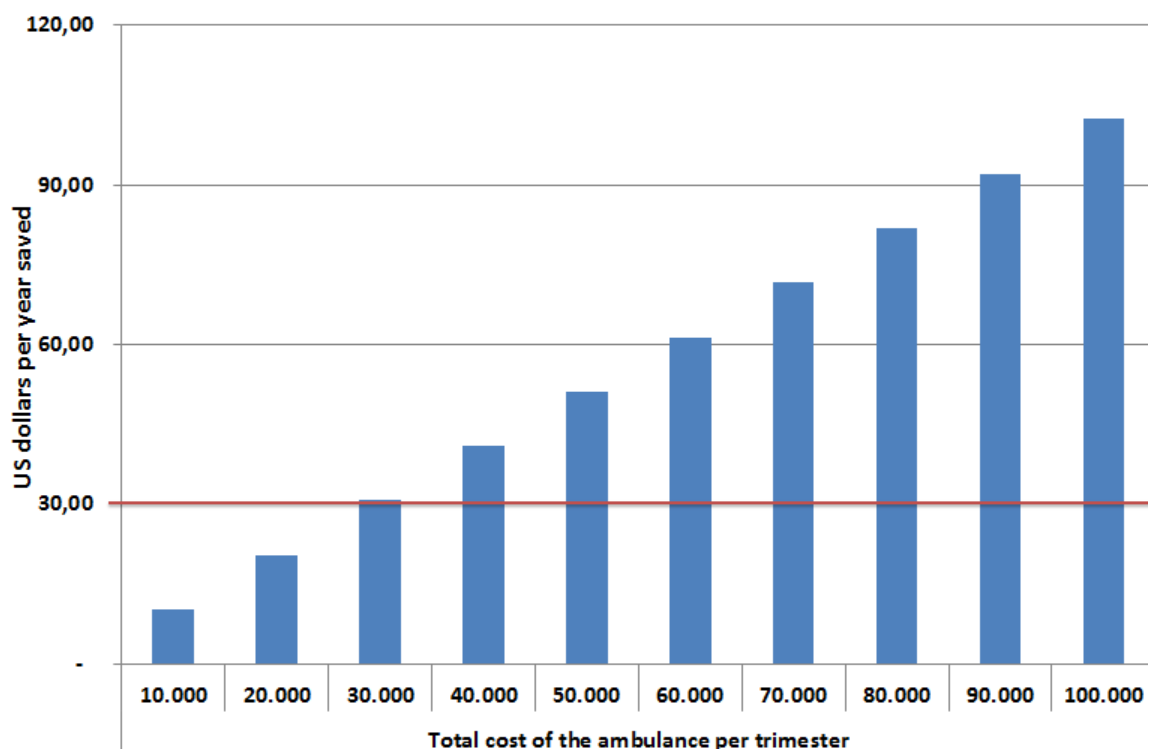


Figure 3 Sensitivity changing the cost of the ambulance.

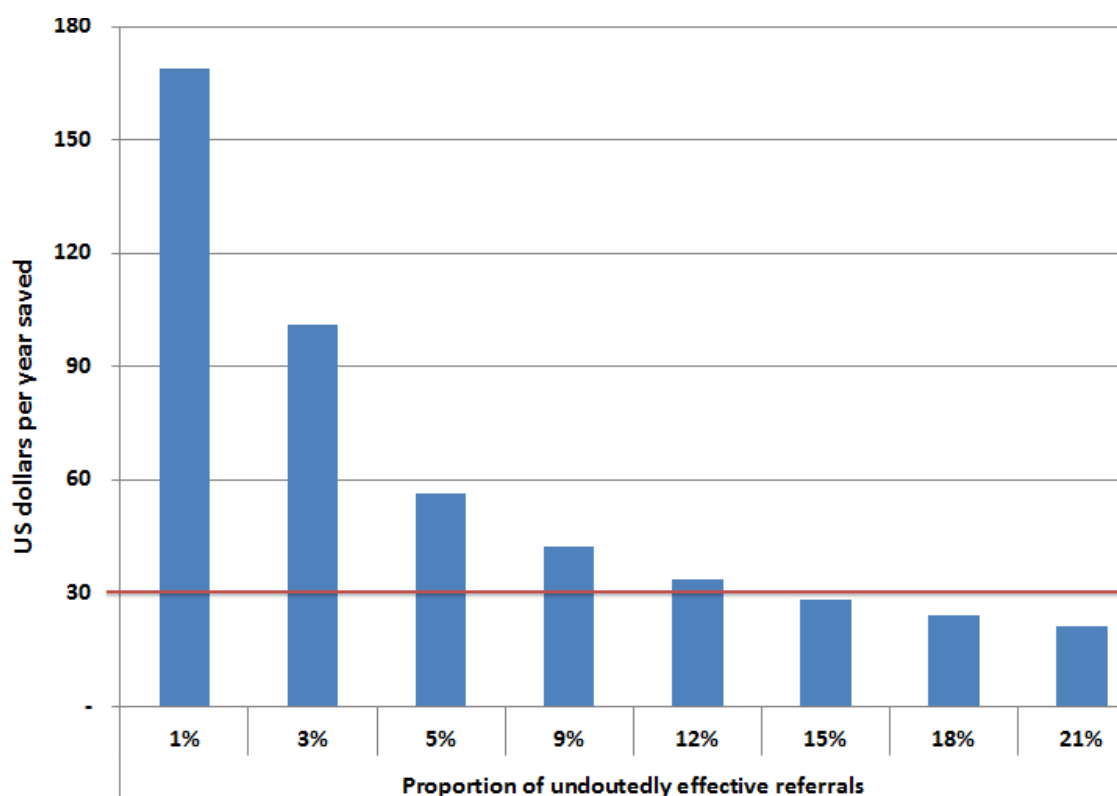


Figure 4 Sensitivity changing the number of undoubtedly effective cases.

Considering together the UE and PE cases, the sensitivity analysis changing the total costs shows that the intervention remains very attractive until the total costs increase up to 127.849 US Dollar (below 30 USD cut-off), equivalent to almost 2 times the actual expenses of the ambulance. Furthermore, the intervention has been found to be attractive when the total costs reach 639.243 US Dollar (below 150 USD cut-off) and acceptable at 2.288.490 US Dollar (below 537 USD cut-off).

## Discussion.

The aim of this study was to detect the cost-effectiveness of the ambulance service for obstetric emergencies in the district of Pujehun Sierra Leone; the analysis is an approach to monitor the development of the intervention in order to allow for future improvements.

The study was inspired and takes as models two similar analyses previously conducted on similar topic; the first by the NGO Medici con l'Africa CUAMM in 2011 and the second by the NGO Médecins sans Frontières MSF in 2013.

The first is referred to the ambulance service implemented in Oyam, the northern district of Uganda. It was conducted a cost-effective analysis of the service in respect to the improvement of the access and of the quality of reproductive health. This analysis is highly similar with the one conducted in Sierra Leone; in fact, similar are the methods for collecting the data on the costs and for evaluating the clinical effectiveness. Identical are also the thresholds to compare the evaluations; if < 30 US Dollars the intervention is considered very attractive, if < 150 US Dollars is attractive and if < 490 US Dollars, the Gross Domestic Product per person per year in the country, acceptable. However, the final result differs with a cost per life years gained of 15,82 US Dollars with 3% discount rate on the life years gained concluding the ambulance service in the district of Oyam to be very attractive. Despite in the CUAMM study only 12% of the total cases were considered UE, the favorable final outcome has to be attributed to the particularities of the inputs included in the analysis. In fact, the total costs calculated were very low, about 9.675 US Dollars almost 86 % less than the total costs for the ambulance service in Pujehun. The life expectancy at birth was higher than the one in Sierra Leone, in Uganda in 2011 was about 58,5 years old (World Health Organization, 2006); finally, the geography of territory did not contribute to obstacle the implementation of the referral system. (Edgardo Somigliana, 2011)

The aims of the study conducted by the MSF in Kabesi, a rural district of Burundi were to describe the ambulance service and the communication system of the district, to examine the association between the travel time of the ambulance and the deaths of the mothers and newborns, and to evaluate the impact of the ambulance service on covering the EmONC and the caesarean sections. Despite it was not conducted a cost-effectiveness analysis, the study demonstrated an effective implementation of the communication and transport system for obstetric emergencies in Kabesi. The similarities between the Kabesi study and the study in Sierra Leone are associated several factors; the retrospective view adopted, the methods used to collect the data for the costs and also for the setting of the implementation; and the composition of the land. In fact, the terrain is mountainous, most of the roads are in bad conditions and difficult are the connections; additionally, the transportations are few and expensive for the poorest. The ambulance service evaluated in Kabesi is highly similar with the one in Pujehun; however, regarding the final outcomes, it is not recommended to compare the two studies due to the different analysis conducted, one cost-effective and the other solely focused on the effectiveness. (MSF, 2013)

The analysis of this study in Pujehun reports the ambulance service to cost 49,32 US Dollar, this indicates the intervention being attractive because less than the cut-off of 537 USD and more than 30 USD. Furthermore, discounting the effects by 3% the intervention remains attractive costing 74,14 US Dollars per life year gained. The same conclusion was confirmed by the sensitivity analysis both when changing the costs and when changing the proportion of the UE cases. The two analysis establish the robustness of the final results and clearly emphasize the huge impact that the total costs have on the final outcome. In fact, moving together the total costs and the total life years gained the most favorable result is achieved when the proportion costs-effects is 3:1. In order to reach the very attractive case, the costs of referral system should decrease by 3 times or, on the other side, the undoubtedly effective cases should increase by 3 times.

The study has several strengths and limitations that have to be considered.

Beginning with the strengths, the analysis followed a meticulous method where the strong collaborations of the experts teams in loco in Sierra Leone and in Italy is essential. The results obtained have strongly been debated with a positive agreement by experts having several years of experiences in the field.

The data used are very detailed and specific to the context; however, the methodology of the collection of the data and their analysis leads to consider the work a scientific and highly comparable study. Although it is not the most favorable, the final outcome gained is positive and encouraging for investment and for the future improvement of the referral system.

Very sensitive strength is the constant presence of qualified staff on the ambulances and at the call center in the hospital of Pujehun. On one side this has contributed to increase the costs, but on the side of the effects, it was considered a training for better prepared personnel and a great investment for a successful future of the service.

Moving to the drawbacks, the limitations for this studies are numerous.

Firstly, many are the assumptions concerning the total costs and final data are both real data and estimations; this may have led to data correlated with errors. In fact, many difficulties have been faced during the collection of data, from the unstable situation of the Italian monitoring team settled down in Pujehun only in June, to the difficulties in managing the new innovative project since January by the team in loco.

Secondly, the clinical criteria used to evaluate the effectiveness of the referrals can be considered very strict and rigid. Additionally, the choices of these criteria were merely decided by the team of expert physicians and only in part it was taken into account the literature. This is also related to the particular environment of the district of Pujehun. The roads not asphalted, the lands crossed by rivers that make the drive complicate, the impossibility to reach certain villages and health units due to floated roads, and non-existent alternatives for transportation, lead the type of transport not to be a significant variable. In fact, despite the transport used to reach the main hospital, the travel times would have remain very long. Being this the case, the service of ambulance can make the difference mainly on those referrals considered clinically moderate and only in part on those crucial. With moderate cases are indicated the cases where longer travel times could cause irreversible complications especially in a rural low resources setting. Therefore, the standard medical judgement remains the starting and referring point for the clinical evaluation of the referrals; however the significant and final decision was based on the experience that the physicians had in the field in African countries.

Furthermore, if the criteria would have been less based on the physicians experience and more on the general knowledge of medicine, the number of undoubtedly effective cases could have been more and this would have led to different results. This is clearly evident when both possibly and undoubtedly effective cases are included leading the intervention to be considered very attract with a cost per life year gained of 13,23 US Dollar. Additionally, the change in the results do not consider the possible impact and change in the total costs that remain constant. This is due to the fact that the only costs that could have changed including the PE cases are only those related to the health assistance. These are not considered to have a consistent impact on the final outcome and therefore they were excluded from the analysis.

Extremely relevant is the assumption regarding the criteria for the effectiveness; it has been assumed that the mothers and/or the newborns would have died immediately and in any case without the transportation with the ambulance. However, despite the life-threatening health conditions of the mothers and the newborns, it cannot be affirmed with absolute certainty that the absence of transportation would have led to death.

It can be noticed that the ambulance service had a major impact on the mothers compared to the newborns. According to the physicians who have evaluated, this outcome has three explanations. As first there is the clinical reason for transferring the mothers to the main



hospital in Pujehun; many of the findings of transfer reported can cause the death of the newborn in a few hours. Cases of asphyxia or ischemia (untimely detachment of the placenta, uterine rupture, placenta previa with bleeding even if minimum etc.) are incisive for the newborn while the conditions of the mother could still be considered relatively stable. In these cases, the time is the key and essential factor that makes the difference. Secondly, significantly connected with the previous point, it is the serious and widely known problem of the incapacity of the medical staff in the neonatal resuscitation. The lack of trained personnel, equipment and supplies, lead to the death of approximately 10 million newborns each year due to shortness of immediate breathe. (Wall SN, 2009) Despite the fact that the latest update numbers seem to show an improvement with 2,7 million newborns dying during their first month of life (HNN, 2016), in recent years little was invested in programs for newborns compared to other interventions. Consequently, the care provided to the asphyxiated newborns is precarious and insufficient reflecting the high neonatal mortality. Third, healthy newborns were referred due to the mothers conditions. Post-partum hemorrhage and post-post-partum sepsi are extremely threatening for mothers and, without the ambulance intervention they are causes of certain death.

Additional limitation is that the study is retrospective; therefore, it was not possible to avoid missing data. A prospective study would have led to more precise data.

The extremely low life expectancy of Sierra Leone has a huge impact when calculating the life years gained; higher life expectancy would have led to lower cost per life year gained. This is the case of Uganda where at time of the study the life expectancy at birth was 58,5 years old significantly higher than the 46 years old in Sierra Leone.

Lastly, the orography of the district and the numerous geographical barriers did not help the success of the service. The long distances and the presence of rivers increase the time taken to reach the PU main hospital and therefore decrease the probability of undoubtedly effective transport. The provenience of the referrals highly impacts both the total costs and the effectiveness of the transport; it results that almost 30% of the referrals were not from the mainland.

The results achieved from the implementation of the ambulance service in Uganda were then used as a comparator. Palpable differences are in the costs reported and mainly related to the costs for the ambulance itself. The ambulance service in Sierra Leone involved the use of tree

ambulances while in Uganda only one was used. Adding all the costs for the maintenance, insurance and fuel, it becomes evident the major impact that the total costs had on the cost per life years gained in the district of Pujehun compared to Oyam. On the side of the effects, the total years gained are negatively affected by the high difference in the life expectancy of the two countries.

Concluding, there is the need for a future cost effectiveness analysis with more probability of positive results having now more experience and knowledge regarding the situation and knowing the aspects to monitor. Additionally, the new data collection started in January 2016 has already presented improvements in the method adopted and a more precise analysis.

### **Conclusion.**

Concluding, the study reports the intervention to be cost-effective with a cost per life year gained of 70 US Dollars. Additionally, it is relevant the great increase in the total number of institutional deliveries. The referral system has been implemented in an area extremely poor of humanitarian and health resource and where the drastic disadvantages in the communication and in the transportations contributed to increase the huge gap and the challenge faced. In order to verify the cost-effectiveness of the ambulance service implemented by CUAMM and its impact in reducing the maternal and neonatal mortality, the intervention should be also realized in areas with less but similar needs. The health needs, the barriers in the transportation to the main hospital, the affordability of the services, the long distances and the cultural issues, target the district of Pujehun as a borderline case. Finally, to the analysis should be integrated with a more detailed data collection and a more frequent monitoring of the service's development. *“Coupled with good quality care, an effective referral system is a key factor in reducing maternal mortality and neonatal mortality”*. (CUAMM, 2016)

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