COST-EFFECTIVENESS OF EMERGENCY OBSTETRIC CARE IN BOMET COUNTY: COMPARING AMBULANCE TRANSFER AND SELF-REFERRAL

RICHARD KALISA

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DECLARATION

This research paper is my original work and has not been presented for any award of degree in any other University.

Signature…… Date……

Richard Kalisa

X53/88392/2016

This research paper has been submitted for examination with my approval as university supervisor.

Signature…… Date……

Dr. Moses Kinyanjui Muriithi

DEDICATION

This dissertation is dedicated to my parents Late Josephine Mukamukwadi and Marcel Twamugize for being my role models and giving me the opportunity to have a good foundation of education. I will always miss your love and care; Mum and Dad thank you for always telling us that knowledge is power. You are the pillars in my life, and I am really indebted to you. Be blessed always. To all these mothers whose data lead to this research paper. I would not have been in position to accomplish this critical milestone in my educational lifestyles – thank you each and every one!

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ABSTRACT

Background: Obstetric complications are difficult to predict and may require referral, expedited by ambulance use. We conducted a cost-effectiveness analysis among women admitted with obstetric emergencies through comparing ambulance transfers and self-referrals in a predominantly rural setting in Kenya.

Methods: A cross-sectional study compared women who had been admitted with obstetric emergencies delivered by either ambulance or self-referral at Longisa country referral hospital (LCRH) between January to June 2019. A cost-effectiveness analysis (CEA) was adopted using a healthcare system perspective being the county government of Bomet. Direct costs needed for ambulance, self-referral and clinical care were calculated. Every woman admitted with a pregnancy-related complication was assessed using the adapted sub-Saharan African Maternal Near Miss (MNM) criteria. Each referred woman was categorized as: 'necessary referral' meaning that they were managed for either MNM or potentially life-threatening complications (PLTC) and 'unnecessary referral' meaning those with no obstetric complications. Incremental cost effectiveness ratio (ICER) for referral was considered attractive or very attractive interventions when costs per life years gained (LYG) were below $150 and $30, respectively.

Results: Overall, 2804 women (96.3%) were self-referrals, while 108 ambulance transfers occurred (3.7%). Main indications for ambulance transfer were prolonged labor (*n*=21; 19.4%), pre-eclampsia/eclampsia (*n*=19; 17.6%) and sepsis/peritonitis following cesarean section (*n*=15; 13.9%). Necessary referrals were considered to have occurred in 81/108 (75%) for ambulance transfers versus 239/2804 (9.3%) self-referrals. If all necessary referral cases had exclusively used ambulance services (ambulance + self-referrals), then the total intervention costs would be $90,112 and LYG 6095, equivalent to ICER of $14.8 per LYG. Women with unnecessary referrals by ambulance were 27/108 (25%) versus self-referrals in 2565/2804 (91.5%) showing that these women could have been managed in sub-county hospitals or health centers.

Conclusions: Cost-effectiveness of reasonably well-targeted ambulance services on women with MNM or PLTC in our setting was very attractive.

Keywords: Ambulance, Cost-effectiveness, Economic evaluation, EmOC, Maternal morbidity, Maternal near miss, Quality of care

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LIST OF ABBREVIATION

CBA	Cost Benefit Analysis
CEA	Cost Effective Analysis
CER	Cost Effectiveness Ratio
CMA	Cost Minimization Analysis
CS	Cesarean section
CUA	Cost Utility Analysis
EmONC	Emergency Obstetric and Neonatal Care
GDP	Gross Domestic Product
HCs	Health Centers
ICER	Incremental Cost Effectiveness Ratio
KES	Kenyan Shillings
KRCS	Kenya Red Cross Society
LCRH	Longisa County Referral Hospital
LMIC	Low- and Middle-income Countries
LYG	Life Years Gained
MDGs	Millennium Development Goals
MMR	Maternal Mortality Rates
MNM	Maternal Near Miss
NHIF	National Health Insurance Fund
NNM	Neonatal Near Miss
SBA	Skilled Birth Attendant
SDGs	Sustainable Development Goals
SMO	Severe Maternal outcome
USD	United States Dollars
WHO	World Health Organization

OPERATIONAL DEFINITIONS

Ambulance: A modified vehicle with specialized fittings used to transport sick people to, from or between places of treatment during their illness.

Associated conditions: diseases that can lead to a severe maternal outcome but are not among sequences of events resulting to a severe maternal outcome case.

Emergency referrals: transferring of medical conditions endanger life.

Intrapartum stillbirth: Newborn ≥ 28 gestational weeks died during labor/delivery.

Live birth: birth of baby who breathes.

Maternal death: death of parturient women between conception to end of puerperium period, but not from incidental or unintentional causes.

Maternal Near Miss: a parturient woman who nearly died but survived a complication that would occur from conception to the end of puerperium period.

Potentially life-threatening conditions are different categories of obstetric conditions including diseases that can endanger a parturient woman's life from conception, labor and after termination of pregnancy.

Referral system: a mechanism that allows patients to use resources when accessing care that maybe beyond their reach.

Self-referral: A woman who is presented to the hospital without following formal referral channels or presented directly from home with emergency obstetric complication.

Severe maternal outcome: sum of maternal deaths and maternal near miss cases.

Transfer: a process via which a client is moved from one facility to another for purposes of medical care.

Transport referral: The system and referral protocols used when transferring patients from one level facility to the next level of care.

CHAPTER ONE: INTRODUCTION

1.1 Background

According to WHO (2019) about 295,000 parturient women died during pregnancy and childbirth in 2017 globally, most of them in low-income countries (LICs). This has been attributed to delays in seeking, reaching and obtaining adequate care upon arrival in health facilities (Thaddeus & Maine, 1994). Hofman et al (2008) and Hussein et al (2012) reported early detection of high-risk pregnancies, management of obstetric related complications and provision of skilled birth attendance (SBA) had emerged as strategies to reduce maternal mortality ratios (MMR). While Hussein et al (2012) and Somigliana et al (2011) highlighted transport barriers were generally neglected.

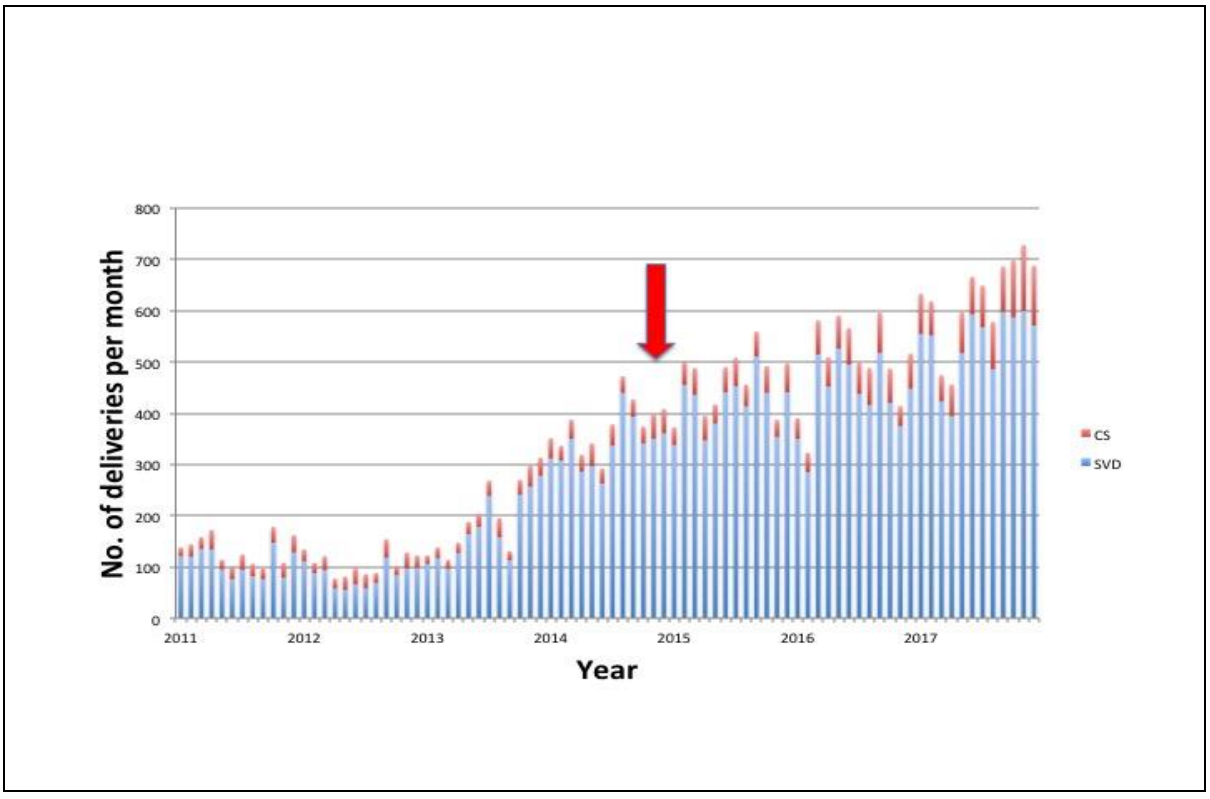
The World Health Organization (WHO) (2015) and Kassebaum et al (2016) reports a reduction in MMR has been attributed to improved access to Emergency Obstetric Care (EmOC). In Tanzania, almost half (48%) of the women with delayed referrals reached appropriate level of health facility in two or more days Pembe et al (2010) and in Uganda by Kobusingye et al (2005) only half reached health facilities the same day. Additionally, Hussein et al (2012) conducted a systematic review which demonstrated two-thirds of all pregnant women who used health facilities went to two or more hospitals in the process of seeking care. This could be explained by persistent challenges to provide skilled manpower and equipment in facilities, and by communication breakdowns and insufficient referral systems between facilities in LICs, hampering timely access to care Hussein et al (2012), United Nations (2014) and United Nations (2015).

By 2015, most sub-Saharan African countries (SSA) including Kenya had reduced their MMRs by 30%, short of MDG 5's target of 75% (WHO (2015). In the United Nations (2014) and United Nations (2015) reports showed how the Government of Kenya (GoK) joined other countries in expressing political commitment towards increasing access to quality obstetric care as well as improving the health system to attain the Sustainable Development Goals (SDGs) by 2030. In June 2013, GoK declared that maternity care services in public health facilities should be provided free of charge whereby the central government would reimburse all birth-related costs to providers. This was followed by the First Lady's launch of the Beyond Zero Campaign in 2014 in Kenyatta (2020), an initiative that provided fully equipped ambulances to all 47 county governments. Furthermore, in

2018, GoK renewed its commitment to provide free services to all expectant women through a scheme called the Linda Mama Program Benefit Package. This aimed to increase SBA through provision of free antenatal care (ANC), ambulance services, midwifery and surgical services during childbirth and postnatal care (NHIF (2018).

Together with those national efforts, in 2015, the County government of Bomet had a lease agreement with the Kenya Red Cross Society (KRCS) to offer comprehensive services including a fully serviced ambulance, combined with emergency medical equipment and paramedic availability in each ambulance, which resulted in increased SBA (S1 Fig). For pregnant women who live in rural areas like Bomet County, free transport to health facilities is paramount to save them several hours walking to access EmOC. As part of evaluating the implementation of this ambulance intervention, we conducted a cost-effectiveness analysis of emergency obstetric care comparing ambulance transfers to self-referrals among women admitted with obstetric emergencies at LCRH, Bomet county, Kenya.

Figure 1: Number of deliveries at LCRH, Bomet; 2011-17



NB: The red arrow shows when Kenya Red Cross Society ambulance service were started.

1.2 Problem statement

Globally, measures to strengthen healthcare referral system are being developed with focus on patients' needs. There are also measures put in place to understand more about common barriers for successful referral. In LICs such as Kenya, available ambulances meant to enhance referral services do not perform to their expectation due to poor ambulance fuel/insurance/maintenance and communication challenges affecting their efficiency Hofman et al (2008). Rutton et al (2018) and Kalisa et al (2019) demonstrated a unique opportunity as compared before to address the communication challenges while using ambulance services through the wide acceptability and impressive diffusion of mobile phone use in most remote settings.

Similar to other African countries, Kenya's health system is composed of the highest level of tertiary facilities providing specialized health care, secondary and primary care facilities being the lowest levels of care. The health services are also provided through faith-based hospitals, private health facilities, and traditional healers. However, due to poor referral systems across all levels of health care has resulted into congestion of tertiary and county hospitals directly affecting their health services performance Gitonga et al (2013). Since 2013, it has been the mandate of the counties to provide health services, pharmacies and manage referrals Gitonga et al (2013).

The Kenya Health Policy MOH (2012a) and Kenya Health Sector Strategic Plan (KHSSP) MOH (2012b) have identified measures to address the referral system challenges to improve patient outcomes as well as efficiency in the health system. These policies have resulted in development of standard referral guidelines that respond to challenges and needs of the populace and healthcare system.

The Kenya Demographic Health survey (2015) showed almost half of pregnant women (47.8%) still gave birth at home in Bomet county possibly due to inadequate modes of transport especially ambulance services from most remote areas consequently delaying the management of life - threatening complications among expectant women. Although, the GoK has started free maternal health care, together with county government of Bomet paying for the ambulance referrals for pregnant women to enhance efficiency in the referral system. Thus, to reduce delays in seeking, reaching and increased skilled birth attendance. As means to identify and

recommend focused and context-specific solutions to the problem of referral in maternal health. We conducted a cost-effectiveness analysis of emergency obstetric care comparing ambulance transfers to self-referrals among women admitted with obstetric complications at LCRH, Bomet county, Kenya to provide county health policy makers with a tool to make rational choices.

1.3 Research Questions

1. What are the total costs involved among obstetric emergencies delivered by ambulance and self-referrals at LCRH, Bomet County?
2. What are the total benefits involved among obstetric emergencies delivered by ambulance and self-referrals at LCRH, Bomet County?
3. What is the cost-effectiveness and incremental cost-effectiveness under ambulance and self-referrals among obstetric emergencies delivered at LCRH, Bomet County?
4. What are the policy recommendations deviated from our findings?

1.4 Objectives

1.4.1 General Objective

To conduct a cost-effective analysis of emergency obstetric care comparing ambulance and self-referrals among women admitted with severe obstetric complications in LCRH, Bomet county.

1.4.2 Specific objectives

1. To estimate the total costs involved among obstetric emergencies delivered by ambulance and self-referrals at LCRH, Bomet County.
2. To compute the effectiveness amongst ambulance and self-referrals at LCRH, Bomet County.
3. To compute the cost-effectiveness ratio and incremental cost-effectiveness ratio under ambulance and self-referrals among obstetric emergencies delivered at LCRH, Bomet County by life years and cost per life year gained.
4. To make policy recommendations from specific objectives 2 and 3.

1.5 Significance of the Study

Efficient use of resources is key to Kenya's attainment of Vision 2030. This research paper estimated the cost-effectiveness and impact of ambulance use and self-referrals to offer insight into efficient resource use. The research revealed the costs involved while treating different severe maternal morbidities. Globally, maternal deaths are still a public health challenge, but it is our hope that the economic evaluation lessons from our findings will provide relevant literature on cost-effectiveness of severe maternal morbidities.

This study was relevant to the GoK and the ministry of health in assessing the current health assistance related costs and financing available in relation to severe maternal morbidities in the country. Now, through the central government alongside the county governments intervenes in the provision of maternity care by financing directly and through the national health insurance, health care costs stay high for most households especially for the poor. The study provided a snapshot of some key factors where the government and other relevant stake holders may need to invest in order to effectively manage as well as lower the severe maternal morbidities rates.

Our study paper identified some of the gaps and recommended future research areas which the researchers can undertake.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical Literature Review

The Grossman model of health production perceives good health as a commodity, which can be affected by the market forces of labour and productivity. It also highlights that the healthcare demand is affected the effects (good health) and not just medical services provided.

Grossman et al (1972) noticed that when economists emphasize on healthcare demand for an expense of demand for health then traditionally demand theories assume that services and goods bought in markets enter customer's application functions. He further challenged by illustrating a sharp distinction between the essential objects of choice called commodities and market products. Accordingly, consumers produce commodities with inputs of market goods and their own time. For instance, pharmaceutical goods, transportation to produce visits, and medical care to produce good health etc.

Since the services and goods are inputs to produce commodities, the resulted demand for them is a derived demand. Good health in this way is treated like a durable item and a health capital (stock). This model demonstrates how good health exhibits characteristics of a normal stock in the market which depreciates with time and is increased with investments such as good diet, proper medical care, good housing and physical activity. Grossman model demonstrates how demand of health is an investment commodity and how it is influenced by the essential law of downward sloping demand curve. A shift changes the healthcare demand. Lastly, the level of health is dependent on investment of resources for its production at any rate in one section.

There should be an expected increase in the shadow price based on age. However, there will be increased depreciation rate on the shock of health over one's lifespan and reduces even further with lower level of education, since its presumed that the higher educational level the better efficiency of individuals in producing health.

2.2 Empirical Literature

In Mangochi, Malawi, Hofman et al (2008) compared investment, effectiveness and operational costs between motorbike ambulance placed at rural health centers to having a four-wheel drive automobile ambulance stationed at rural district hospital. They used cashbooks, logbooks, referral forms, and maternity registers to collect data for over one-year period. They found a 35%–76% (2 to 4.5 hours) reduction in the median referral delay. Motorbike ambulance costed $508 which was nineteen times cheaper than four-wheel drive automobile ambulance and recommended the possible use of cost-effective motorbike ambulance in low-resource settings.

Accorsi et al (2017) in Oromiya region, Ethiopia assessed the cost-effectiveness of ambulance services specifically for EmONC services. From their prospective cohort study which evaluated ambulance transfers and callouts to St. Luke hospital among women admitted with obstetric emergencies. The medical doctors who treated these emergency cases were told to categorize the latter based severely as undoubtedly effective. Pre and post obstetric referral costs included those needed to run the ambulance services and the extra costs incurred during health care. The local life expectancy tables were used to calculate the quantity of year saved. They found that ambulance was undoubtedly effective. The interventional total cost was $8299 and $24 per life-year saved which is <150 and 30 USD which was outlined as enticing and extremely attractive interventions, respectively. After sensitivity and discount rate analysis done on the cost of the ambulance confirmed the strength of the results. They concluded that the ambulance services for obstetric care in low resources settings was extremely cost-efficient.

In the Ethiopian Oromia region, Tsegaye et al (2016) computed the ambulance costs incurred by women while accessing emergency obstetric care services. Expectant women requiring referral were delivered to nearby health facilities. Women had severe maternal morbidities were referred to health facilities providing EmOC services. Amongst 528 ambulance call outs, 314/528 (59.5%) pregnant women were referred from homes to health centers. Of which, 84/179 (46.9%) pregnant women were referred to hospital with severe maternal outcomes. The ambulance cost incurred per referred pregnant woman was US$ 18.47. They concluded that referral using ambulance services for emergency obstetric care was cost-effective and well used.

Tayler-Smith et al (2013) assessed the costs involved in communication and ambulance services and health effects for preventing maternal and early neonatal deaths in Kabezi district, rural Burundi. Data collection was done using logistics records, patient registers and ambulance logbooks. The overall annual costs incurred were € 85 586 or € 61 per pregnant woman referred. They concluded that implementation of an effective ambulance referral and communication systems to enable access to urgent maternity care was possible and reduced associated maternal and neonatal morbidities and mortalities due to delayed referral.

Somigliana et al (2011) in Oyam district, northern Uganda evaluated an ambulance referral system cost-effectiveness analysis to improve quality and access of obstetric care. They prospectively collected data among women delivered by ambulance admitted with obstetric emergencies for a three-month period. The direct costs incurred for obstetric emergencies were calculated. While obstetric indications were used to identify effectiveness amongst the referred cases. The latter was then measured compared to WHO thresholds. Women admitted with obstetric emergencies identified as effective were 11/92 (12%) equivalent to 612 years saved. Ambulance referral system cost per year saved was $15.82 considered very attractive intervention as since it was half the WHO thresholds. Thus, ambulance services were considered very attractive.

Muchiri et al (2017) assessed the performance of ambulance services in Machakos county, Kenya using parameters like clients' satisfaction, on-seen time, response time and cost-effectiveness. They found that 24.7%, 10.3% and 0.03% of the victims transported accounted for EmONC, accidents and rape victims, respectively. The annual costs incurred were USD 717,639.05 or USD 66.37 per case referred. Their conclusions were that ambulance services are technically efficient. More emphasized the need to address the supply barriers (transport and operational costs) and demand barriers (poor health seeking behaviors, cultural and social).

Goodman et al (2017) conducted a comparative cost-effectiveness amongst quality improvement (QI) intervention and model counterfactual in Accra, Ghana. The study found that after QI intervention; 129 (±13) intrapartum stillbirths and 236 (±5) maternal deaths were averted, equivalent to an ICER of $158 ($129–$195) USD, which was below the $1268 USD threshold of cost-effectiveness. Even after sensitivity analysis considering case fatality rates, annual

prevalence risk factors and DALY calculation still revealed an ICER between $97–$218 way below the highly cost-effective threshold. Their conclusions were QI intervention reduced significantly maternal and neonatal deaths and was highly cost-effective.

Bikilla et al (2009) in an Ethiopian district hospital demonstrated that ART use accounted for 7.1 extra LYG compared to antiretroviral treatment (ART) naïve HIV clients using a Markov model cost-effectiveness. Additionally, the incremental costs per LYG undiscounted and discounted enhanced that ART-use was below the per capita GDP threshold. Therefore, ART use among HIV patients was considered as cost-effective intervention in routine clinical care in Ethiopia.

Babigumira et al (2009) in Uganda, conducted cost effectiveness of facility-based care (FBC), home-based care (HBC) and mobile clinic care (MCC) in provision of ART using Markov modeling and decision among AIDS patients in WHO Clinical Stage 3 and 4 from the ministry of health perspective. The study found that 10-year mean costs per AIDS client were $3212 for FBC, $4782 for MCC and $7033 for HBC. However, the ICER was found lowest for USD 2241 per life-year and $2615 per QALY MCC compared to FBC than $2251 per life-year and $2814 per QALY for HBC versus MCC. Univariate and probabilistic sensitivity analyses revealed FBC still remained cost effective. The most cost-effective intervention to provide ART in Uganda was FBC and efforts towards its implementation should be scaled up in Uganda.

Hogan et al (2010) evaluated the cost-effectiveness of a scope of mediations for averting HIV spread and for HIV treatment regarding to attainment of MDG 6 goal. The study was conducted using a cost effectiveness based on an epidemiological model for South East Asia and sub-Saharan Africa due to their high mortalities. Their results showed that HIV transmission could be accomplished most efficiently through treatment of STIs, interventions for sex workers and mass media campaigns. Together, with school-based education, VCT and pMTCT. They concluded that ART was in any event as cost-effective in improving population wellbeing jointly with the interventions studied.

Zimmermann et al (2017) using a societal perspectives and Markov model assessed the cost-effectiveness of Papanicolaou smear (Pap), cryotherapy without screening, visual inspection with acetic acid (VIA) and testing of human papillomavirus (HPV) in Kenya HIV treatment centers.

From treatment center perspective cryotherapy costs incurred were $19, $94, $124, $113, and $99, $196, $219, $223 from societal perspective among women with CD4 200–500 cells/m had undergone VIA, Pap, and HPV, respectively. Among women whose CD4 counts was >500 cells/mL when managed using cryotherapy Pap, VIA, and HPV leading to 19.9+ years of life expectancies and reduced costs i.e., treatment center: $13, $51, $71, and $56 and societal: $49, $99, $115, and $102. VIA was cost effective compared to HPV. They concluded that preventative cryotherapy was cost effective strategy and lead to higher life expectancy.

Globally, if all nations worked together towards measles elimination to accomplish measles global eradication. Based on those assumptions by Babigumira et al (2011), conducted a cost-effectiveness analysis on measles eradication in Uganda. Using a dynamic age-structured compartmental model of measles transmission, they showed that 130,232, 3520 and 106330 measles cases, deaths and DALYs could be averted by 2030 based on the measles elimination by 2020. The 2020 measles elimination could avert $556 per DALYs by 2030 and $284 per DALYs by 2050 making it a cost-effective strategy for Uganda.

2.3 Overview of Literature

Prior literature on referral system cost effectiveness for ambulance use among emergency obstetric care conducted by Accorsi et al (2017), Somigliana et al (2011), Tayler-Smith et al (2013), Tsegaye et al (2016) concentrated either on costs or benefits but missed comparing both. However, some literature only looks at one model and concludes that it is cost effective analysis study. In our research paper we used opportunity costs of each service to measure the costs. Both the costs and benefits were counted and measured. Our economic analysis showed relative cost-effectiveness of each model. As mentioned by Somigliana et al (2011), Tayler-Smith et al (2013), Tsegaye et al (2016) while assessing effectiveness among cases they all used theoretical judgment raising concerns about their evaluation being subjective among those cases considered as “Undoubtedly effective”. Therefore, our research paper was the first cost-effective analysis to be conducted on ambulance referral system versus self-referrals among obstetric emergencies using adapted sub-Saharan Africa MNM criteria by Tura et al (2017) as a clinical judgment tool for effectiveness, thus, we attempted to fill that gaps of the prior study limitations.

The increasing focus on maternal health care is a pointer but there is still need for more evidence to what is already available. In Kenya, inadequate data on transport means could hamper responsive strategies as well as development of health interventions. Thus, need for useful information about cost-effectiveness of ambulance referral system among obstetric emergencies from rural setting was paramount.

To best of our knowledge no similar study had been conducted in Kenya on the economic profile of referral system in the field of maternal health with focus on obstetric emergency care. Therefore, in a country like Kenya, where women still die due to associated delayed referral during childbirth, high levels of poverty and scarce resources allocated to maternal health care. Our findings intended to help county governments, NGOs, and the communities to mobilize and institute referral intervention programs that are more cost-effective to address challenges attributed to delayed referral system for maternal and infant survival.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

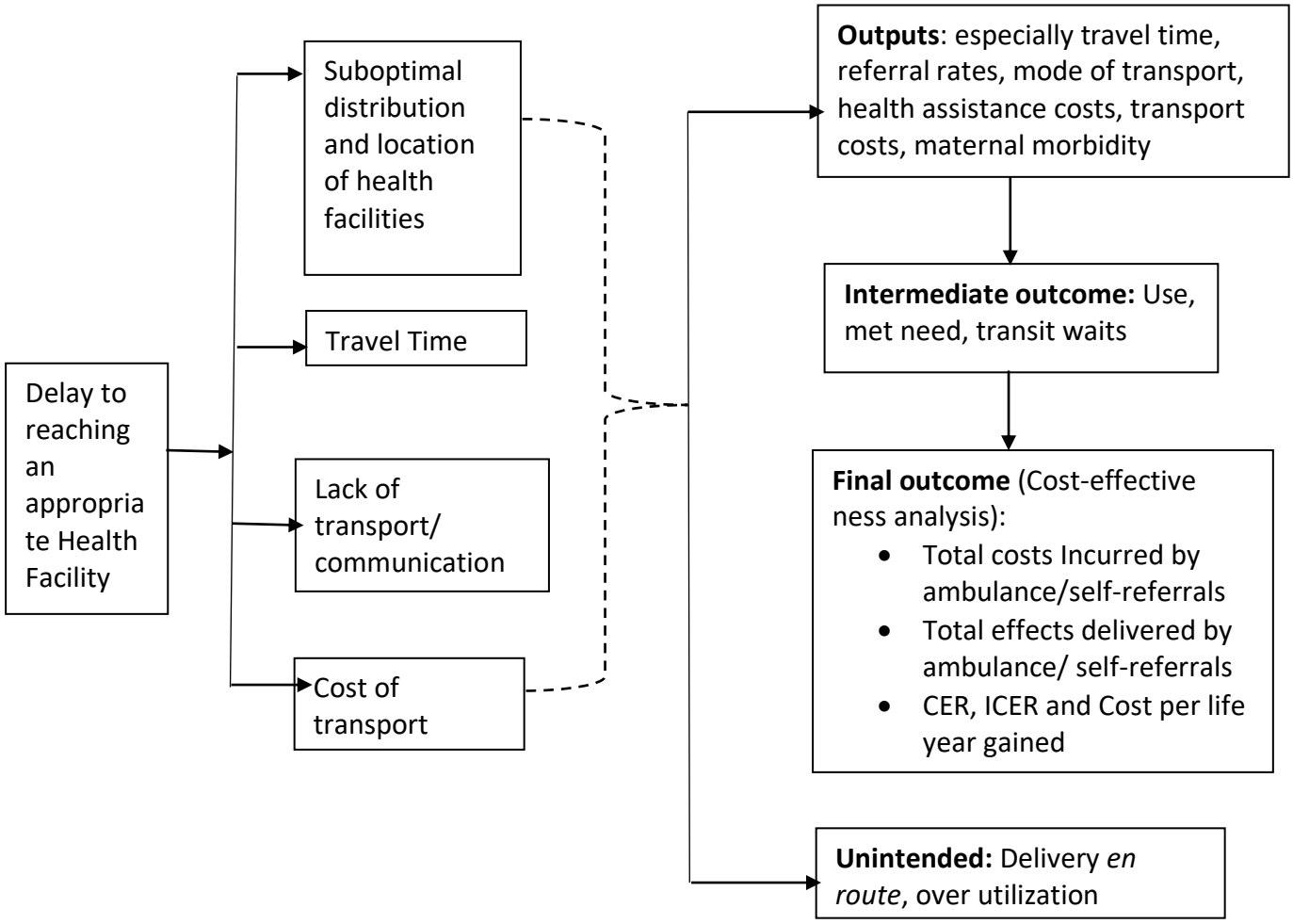
This chapter discusses the methodology what was used for this study paper. It contains the conceptual framework, study design, data source, description of steps for analyzing cost-effectiveness, quality control and ethical considerations.

3.2 Conceptual framework

Banda et al (2015) and Chauhan et al (2016) reported that women from rural settings in Low-Middle Income Countries (LMICs) while accessing care experience many barriers. Therefore, our research paper was based on conceptual model formulated by Thaddeus & Maine (1994) called "Three Delays Model" to examine the causes of maternal mortality especially explaining how the referral procedures are undergone in low resources countries. The first is delay in seeking care, which can be due to socio-cultural factors, unawareness of obstetric dangers, or bad prior experience while at health facilities. Second delay is the difficultly in reaching care as result of long distances pregnant women endeavor when accessing health facilities, lack of affordable transport or poor roads. Lastly, the third delay is result of inadequate care due to the negative health care providers attitudes, shortage or poor skills of health care professionals, inadequate supplies and basic equipment. This study focused on the second delay.

The Three Delays Model framework considers delays that contribute to maternal morbidity/mortality specifically. This research paper was more concerned about personal experience among expectant mothers who had been managed as potentially life-threatening conditions (PLTC) and maternal near miss (MNM), their transport and medical related costs. Therefore, data was collected from maternity and ambulance records among women who had both experienced MNM and PLTC case. With the assumptions highlighted that women who had MNM and PLTC were likely to also experience hardships in accessing appropriate and adequate transport in the event of an obstetric emergency.

Figure 2: Conceptual framework of the study



3.3 Study design

A cross-sectional study compared women who had been admitted with obstetric emergencies delivered by either ambulance or self-referral at Longisa country referral hospital (LCRH) between January to June 2019. The study tested the hypothesis on whether an increased number of ambulance transfers among women managed for either MNM or PLTC as compared to women without obstetric complications at onset of referral who would opt to use other modes of transport.

3.4 Study setting

This study was conducted from Bomet county located in the south rift valley, Kenya and occupies an area of 1,630 km^2. It is comprised of five constituencies (Bomet East, Chepalungu, Bomet Central, Konoin and Sotik). The Kenya Demographic Health survey (2015) estimated population of 891,390 inhabitants, a fertility rate of 4.3 and skilled birth attendance rate of 52.2% in Bomet county. The total number of 145 health facilities consists of one public referral hospital (Longisa county referral hospital, LCRH), two faith-based hospitals, five sub-county hospitals, 23 health centers and 114 dispensaries. All public health services are financed by the county government of Bomet.

The County government of Bomet was selected because it was among one out of the four counties who had signed lease agreement with the Kenya Red Cross Society (KRCS) to obtain comprehensive services including a fully-serviced ambulance, emergency medical equipment and a paramedic for each ambulance since 2015. Additionally, at LCRH the data site, services provided include comprehensive emergency obstetric and newborn care (CEmONC) and 24-hour ambulance services free-of-charge to transfer women from their villages or health centers in case of obstetric complications. The faith-based and sub-county hospitals also provide CEmONC services and have access to the same ambulance services. The county government of Bomet owns two ambulances and hired four from Kenya Red Cross Society; three of the hired ambulances were located in in LCRH of which are our economic evaluation assessment was based. Each ambulance operates independently, covering distances between LCRH and health centers ranging from 2 to 48 km.

3.5 Target Population

3.5.1 Inclusion criteria

All parturient women who arrived either with ambulance or self-referral in LCRH irrespective of their gestational age. These obstetric complications included abortion related complications, ectopic pregnancy, antepartum hemorrhage, pregnancy induced hypertension complications, prolonged/obstructed labor, postpartum hemorrhage, postpartum sepsis, and other obstetric morbidities.

3.5.2 Exclusion criteria

We excluded parturient women who had developed obstetric related complications after postpartum period.

3.6 Sample size estimation

Yamane (1967) formula was used to determine the sample size, using a precision level of 0.05.

$$n = \frac{N}{1 + N(e)^2}$$

Where;

n is the sample size

N is the population

e is the level of precision.

The total number of women usually admitted to LCRH with various obstetric complications per month was about 450, equivalent to 2700 women who attended the facility over six months.

Applying Yamane formula to determine our sample size for our study:

$$n = \frac{2700}{1 + 2700\ (0.05)^2}$$

The sample size of 348 women with obstetric emergencies was used for this study.

3.7 Data Sources and Description of the Variables

3.7.1 Data sources

Obstetric data was retrieved from obstetric records among women who had been admitted with obstetric complications at Longisa county referral hospital, Bomet county. Additionally, individual patient cost data was also be collected through review of ambulance call log books, referral registers, prenatal registers, delivery registers, financial records, and death registers. Data collected included audit on quality of obstetric care among various severe maternal morbidities, transport costs, health assistance related costs and accessibility to LCRH in terms of distance and modes of referral.

3.7.2 Description of variables

Health assistance related costs

The study focused on health assistance related costs and how they interfere with maternal morbidity outcomes. While analyzing the effects of healthcare costs on maternal morbidity, we choose the mode of delivery as the proxy for costs and we used dummy variables coding caesarean=1 and zero if normal or otherwise. The selection of the mode of delivery as a proxy for healthcare only serves to explain the relationship between healthcare costs and maternal morbidity since we appreciate that healthcare costs can be accrued through several other variants of goods and services during and after delivery in the process of consuming health services.

Referral system

Mode of referral was grouped into ambulance transfer and self-referral. Ambulance transfer was a woman brought by ambulance and escorted by health care professionals to LCRH. While, self-referral was a woman who arrived at LCRH after use of other modes of transport like private car, motorcycle or by foot directly from home. Our hypothesis was an increased number of ambulance referrals among women managed for either MNM or PLTC as compared to no obstetric complications at onset of referral who would opt to use other modes of transport.

Transport cost

Access can be due to either financial or physical barriers. Physical access is defined as travel time and distance to reach health facility respectively. While financial access is indicated by transport cost and user fees utilized when accessing care. The transport costs included quantity of fuel used/km, ambulance driver's salaries/incentives, ambulance insurance/maintenance and communication costs incurred during the referral process.

The table below summarizes the variables discussed above and their corresponding measurements.

3.8 Cost-effectiveness analysis (CEA)

3.8.1 Application of CEA

Drummond et al (2005) describes technical efficiency as it compares the effects of alternative interventions and their costs for a given client's group within the available budget. Here, efficiency implies that a given output is achieved at least cost or that the output is maximized at a given cost (Drummond et al, 2005). In CEA, it compares alternatives and measures in natural units e.g., life-years gained. Cost effectiveness analysis is the best method since the comparison is expressed in cost per unit of health effect compared to cost-utility analysis (CUA) that measures an intervention's (morbidity and mortality) and expressed as cost per quality-adjusted life years (QALY) or disability adjusted life years (DALYs).

Table 1: Study variables

Variables **Independent**	**Indicators**	**Data analysis**
Types of obstetric emergencies	• Number of obstetric complications attended • Number of referrals	Descriptive
Health assistance costs	• Number of normal deliveries • Number of surgery procedurals (cesarean section, laparotomy, etc.) • Nature of treatment for obstetric Complications	Descriptive
Transport and communication Costs	• Quantity of fuel used/km • Personnel salaries • Incentives for referrals • Insurance/maintenance • Cell-phone communication	Descriptive
Dependent Cost-effective analysis	• Total costs incurred by women delivered by ambulance versus self-referrals • Total effects among ambulance versus self-referrals • Compute CER, ICER and Cost per life-year gained	Discounting Sensitivity Analysis

3.8.2 Steps to undertake a CEA

3.8.2.1 Perspective of the study

Before performing a CEA, the source of resources to be included in the analysis is paramount as it will be based on the study perspective. Drummond et al (2005) further recommends use of societal perspective as means to capture all changes in resources use regardless of whose budget

is affected, who gains as well as all involved changes in health outcome. Our results were adopted to the health providers' perspective being the county government of Bomet. The scope of this study did not allow for costing of opportunity costs when accessing health care e.g., costs incurred by families, medical costs at primary referring facilities etc.

3.8.2.2 Cost Determination

The resources collected at LCRH are described in detailed below:

Recurrent costs included drivers' and paramedics' salaries, allowances for accompanying drivers and paramedics on night/weekend calls, length of hospital stay, laboratory tests, radiology procedures, clinical care costs incurred during vaginal birth, surgical interventions such as cesarean section or laparotomy and management of other obstetric complications. Other recurrent costs also included ambulance fuel/insurance/maintenance, electricity, water bills, and cell-phone communication. We computed transport costs incurred among self-referrals using Geo-measure area calculator to estimate distance from home or private clinic to reach LCRH, multiplied by costs of fuel per kilometer. We also assumed that women had been accompanied by one person implying transport doubled the costs incurred per woman. Fuel costs for non-obstetric cases were excluded. Hospital costs were calculated based on the National Health Insurance Fund delivery costs NHIF (2018).

The overhead costs were calculated using the allocated shared costs based the time and units of consumption of each shared input as described in WHO (2003). All capital items were identified through physical counts. A review of actual amount from general store records, pharmacy, purchase records, hospitals' supplies, accounts and Kenya Medical Supplies Agency records was conducted for all recurrent items. All costs were presented in Kenya Shillings (KES) and were converted into US dollars (US$) (1 US$ = 103 KES).

The cost of capital resources such as ambulance appeared as a single large amount at the beginning of an evaluation period. Using Drummond et al (2005) we computed the equivalent annual costs based on WHO regional recommendations through annualizing the capital costs.

Therefore, this was done as follows:

$$E = \frac{K - (S/(1+r)^n)}{A(n, r)}$$

Where,

E is the equivalent annual cost

K is the purchase price

S is the resale value

r is the interest rate

n is the useful life of the item

A (n, r) is the annuity factor (n years at interest r), expressed as $(1- (1+r)^{-n})/r$.

The costs in each cost center were added to obtain the total costs. Which were divided by the intervention output to provide the unit cost of delivering the intervention, for example, particularly for our study was the cost of woman admitted with an obstetric emergency. The unit cost was applied in calculating the cost-effectiveness of the study intervention.

3.8.2.3 Measuring health effects

According to WHO (2003), when measuring health effects in CEA it is necessary to compare any changes in the health outcomes of either curative or preventive health interventions. For our study, the outcomes measures were identified MNM and PLTC cases prevented by use of ambulance referral system. However, this evaluation was based on an essential question: is there any other type of transportation, different than the ambulance, which will have the same impact on the survival of the mothers? Therefore, every woman admitted with a pregnancy related complication was assessed using the adapted sub-Saharan African Maternal Near Miss (MNM) criteria by Tura et al (2017). Each referred woman was categorized as: 'necessary referrals' meaning that they were managed for either MNM or PLTC and 'unnecessary referrals' meaning those with no obstetric complications. A necessary referral was assumed to be a woman referred from a lower to a higher level of care, meaning LCRH, where either MNM or PLTC cases were supposed to be managed. An unnecessary referral was assumed to be a

woman without obstetric complications who should have received care at sub county hospitals or health centers.

3.9 Data analysis

Cost data was presented as unit costs for necessary referrals among women delivered by either ambulance or self-referrals. The unit cost per inpatient was obtained by dividing total inpatient cost (capital and recurrent cost) by the total number of admission days used by women categorized as "necessary referral".

Ambulance or self-referral benefits were presented as cost per life years gained for every referral of women categorized as necessary referral based on local life-expectancy tables. This study adopted the WHO reported 66 years for female as their life expectancy in Kenya. To calculate the life expectancy related to the different ages of the mothers, we used the table for "the expectation of life at age" in WHO (1996). The table does report the average life expectancy for each age; clustered in age groups each containing four years, from 1 to 4, 5 to 9, 10 to 14, until 100+. The older the woman becomes the lower her life expectancy, the lower the life years gained when ambulance referral or self-referral were 'necessary referrals'.

Life years gained for every MNM or PLTC case categorized as necessary referral = 66 (average life expectancy) – the expectation of life at the age of the mother (as indicated in the expectation of life for age table).

For each MNM or PLTC case categorized as necessary referral, the same formula was adopted. Therefore, Total life years gained = Total sum of all life years gained for MNM or PLTC case categorized as necessary referral. Finally, our results were derived from formula below:

Cost effectiveness ratio for among self-referrals (CER_S)

$$(CER_S) = \frac{\text{Costs incurred among self-referrals (KES)}}{\text{Effects among self-referrals (LYG)}}$$

Cost effectiveness ratio for among ambulance referrals (CER_A)

$$(CER_A) = \frac{\text{Costs incurred among ambulance referrals (KES)}}{\text{Effects among ambulance referrals (LYG)}}$$

$$ICER = \frac{\text{Costs incurred among ambulance referrals} - \text{Costs incurred among self-referrals (KES)}}{\text{Effects among ambulance referrals} - \text{Effects among self-referrals (LYG)}}$$

We performed a sensitivity analysis using discount rates of 3% and 6%. First, we discounted costs and life years gained (LYG) by 3% for the proportion necessary referrals and later increased the discount of life years gained to 6%. Finally, incremental cost effectiveness ratios (ICER) for the referral intervention were considered acceptable, attractive, or very attractive interventions when costs per gained life years were below Kenya's GDP per person of 1507.8 USD; attractive when < 150 USD and very attractive when < 30 USD as suggested by WHO (1996) respectively.

3.10 Quality control

3.10.1 Research instruments validity

Vigorously trained research assistants who participated in data collection. Questionnaires were pre-tested and modified as necessary and daily completeness check were conducted by the researcher.

3.10.2 Research instruments reliability

We used the adapted sub-Saharan Africa MNM criteria by Tura et al (2017) to assess for reliability of maternal morbidities cases admitted at LCRH that were categorized as "necessary referral" cases. While costs estimation was computed through seven stages used in Hanson et al (1993) to compute unit cost adapted from UNICEF hospital cost analysis manual.

3.11 Ethical considerations

The School of Economics, University of Nairobi first approved the research proposal and ethical clearance was granted from the Institutional Research and Ethics committee of Moi University and Moi Teaching and Referral Hospital (Approval number:0003422). While LCRH administration gave us permission to proceed with the data collection for this study.

CHAPTER FOUR: DATA ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents the results and their discussion through comparison of ambulance and self-referrals among women admitted in LCRH with obstetric emergencies. We used cost-effectiveness analysis to evaluate the implementation of lease agreement between county government of Bomet and Kenya Red Cross Society to provide ambulances services in Bomet County. Data was interpreted under sub-topics below; socio-demographic characteristics and indication for referrals, obstetric causes and management among women admitted at LCRH and computed the cost-effectiveness analysis.

4.2 Socio-demographic characteristics and indication for referrals

During the 6-months study period, 2804 women with obstetric complications admitted in LCRH were self-referrals (96.3%) and 108 were transferred by ambulance (3.7%). Majority of women who presented with either self or ambulance referral were aged between 20-29 years old with median age of 26 ± 6.7 years as well their parity was between 2-4 children with median parity of 2 ± 0.7.

Majority of women who had presented by self-referral were coming from nearby constituencies to LCRH *i.e* Bomet east and Bomet central as compared to ambulance referrals who were resided from far constituencies to LCRH *i.e* Chepalungu, Sotik and Konoin (Table 1).

Main indications for ambulance transfer were prolonged labor (*n*=21; 19.4%), pre-eclampsia/ eclampsia (*n*=19; 17.6%) and sepsis/peritonitis following cesarean section (*n*=15; 13.9%). While self-referral were abortion related complications (*n*=296; 10.6%), prolonged labor (*n*=137; 4.9%) and abnormal fetal presentation (*n*=118; 4.2%)

Table 2**. Characteristics of women admitted in LCRH, Bomet county**

Characteristics		Self-referral	Ambulance
		2804 (%)	108 (%)
Age (years) (median ± SD; 26 ± 6.7)	15-19	586 (20.9)	18 (16.7)
	20-29	1834 (64.5)	53 (49.1)
	≥ 30	384 (13.7)	37 (34.2)
Parity (median ± SD; 2 ± 0.7)	1	695 (24.8)	21 (19.4)
	2-4	1890 (67.4)	63 (58.3)
	≥ 5	219 (7.8)	24 (22.2)
Residence (Constituency)	Bomet East	1360 (48.5)	37 (34.2)
	Bomet Central	776 (27.7)	26 (24.1)
	Chepalungu	431 (15.3)	23 (21.3)
	Sotik	128 (4.6)	15 (13.9)
	Konoin	109 (3.9)	7 (6.5)
Provisional diagnosis	Prolonged labor	137 (4.9)	21 (19.4)
	Pre-eclampsia/Eclampsia	35 (1.2)	19 (17.6)
	Sepsis/Peritonitis post-CS	34 (1.2)	15 (13.9)
	Other complications	39 (1.4) [a]	13 (12) [b]
	Abortion complications	296 (10.6)	11 (10.2)
	Postpartum hemorrhage	42 (1.5)	9 (8.3)
	Uterine rupture	1 (0.04)	6 (5.6)
	Severe malaria	1 (0.04)	4 (3.7)
	Abnormal fetal presentation	118 (4.2)	4 (3.7)
	Road traffic accident	-	2 (1.9)
	Antepartum hemorrhage	24 (0.9)	14 (0.5)
	Previous CS	71 (2.5)	8 (0.3)

[a] Other complications Pyelonephritis (9), Asthmatic attack (1), Hyperemesis (13), Choriamnionitis (8), Endometritis (5), Postpartum psychosis (3)

[b] Other complications Pyelonephritis (3), Asthmatic attack (3), HIV encephalopathy (1), Peripartum cardiomyopathy (1), Postpartum psychosis (1), epilepsy (1), Attempted suicide (1), Idiopathic thrombocytopenia purpura (1), Road traffic accident (1)

4.3 Obstetric causes and management among women admitted at LCRH

Necessary referrals were considered to have occurred in 81/108 (75%) of the ambulance transfers versus 239/2804 (9.3%) of the self-referrals. Ambulance referrals also differed for different causes as compared to self-referrals: for uterine rupture 6/108 (5.6%) versus 1/2804 (0.04%), ectopic pregnancy 8/108 (7.4%) versus 8/2804 (0.3%), postpartum hemorrhage 7/108 (6.5%) versus 42/2804 (1.5%) and pre-eclampsia/eclampsia 20/108 (18.5%) versus 35/2804 (1.2%). Women with unnecessary referrals by ambulance were 27/108 (25%) versus self-referrals in 2565/2804 (91.5%) indicating that these women could have been managed at sub-county hospitals or health centers (Table 2).

Table 3. **Underlying causes, associated conditions and critical interventions done among women admitted in LCRH, Bomet county**[∞]

	Self-referrals			**Ambulance**		
	No complications ∂	PLTC∝	MNM∝	No complications ∂	PLTC∝	MNM∝
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Overall	2565	213	26	27	49	32
Underlying causes*						
Severe hemorrhage						
Abortion	271 (10.6)	15 (7.0)	-	8 (29.6)	12 (24.4)	1 (3.1)
Ectopic pregnancy	-	6 (2.8)	2 (7.7)	-	2 (4.1)	6 (18.8)
Placental abruption	-	8 (3.8)	-	3 (11.1)	1 (2.0)	-
Placenta previa	-	12 (5.6)	4 (15.4)	4 (14.8)	4 (8.2)	2 (6.3)
Postpartum hemorrhage	-	30 (14.1)	12 (46.2)	2 (7.4)	3 (6.1)	4 (12.5)
Uterine rupture	-	-	1 (3.8)	-	-	6 (18.8)
Hypertensive disorders						
Severe pre-eclampsia	-	22 (10.3)	3 (11.5)	-	6 (8.2)	3 (9.4)
Eclampsia	-	9 (4.2)	1 (3.8)	-	9 (18.4)	2 (6.2)
Pregnancy related infections [a]	-	36 (16.9)	1 (3.8)	1 (3.7)	2 (4.1)	3 (9.4)
Sepsis/peritonitis post-CS	-	27 (12.7)	2 (7.7)	3 (11.1)	9 (18.4)	3 (9.4)
Coincidental conditions [b]	-	-	-	-	-	1 (3.1)
Other complications [c]	-	2 (0.9)	-	4 (14.8)	3 (6.1)	-
Associated conditions						
Anemia	58 (2.3)	37 (17.4)	8 (30.8)	5 (18.5)	11(22.4)	9 (28.1)
HIV	193 (7.5)	9 (4.2)	-	1 (3.7)	5(10.2)	3 (9.4)
Previous CS	44 (1.7)	21 (9.9)	6 (23.1)	3 (11.1)	3 (6.1)	2 (6.3)
Prolonged Labor	69 (2.7)	27 (12.7)	3 (11.5)	1 (3.7)	4 (8.2)	5 (15.6)
Critical interventions						
Cesarean section	241 (9.4)	38 (17.8)	13 (50.0)	14 (51.9)	22 (44.9)	7 (21.9)
Laparotomy	-	1 (0.5)	3 (11.5)	2 (7.4)	12 (24.5)	17 (53.1)
Blood transfusion	-	8 (3.8)	12 (46.2)	-	10 (20.4)	22 (68.8)
HDU admission	-	-	9 (34.6)	-	1 (2.0)	17 (53.1)

[∞] Values given as number (percentages). ∝ and ∂ represents necessary and unnecessary referrals

Abbreviations: CS, Cesarean section; HDU, High Dependency Unit; MNM, Maternal Near Miss; PLTC, Potentially life-threatening conditions

*One woman could have experienced more than one cause

[a] Hyperemesis (13), Pyelonephritis (12), Endometritis (5), Choriamnionitis (8), HIV encephalopathy (1), severe malaria (5)

[b] Road traffic accident (1)

[c] Asthmatic crisis(4), Attempted suicide (1), Epilepsy (1), Idiopathic thrombocytopenia purpura (1), Peripartum cardiomyopathy (1), Postpartum psychosis (1)

Ambulance referral as compared to self-referral also differed among associated conditions in women categorized as ‘necessary referrals’: anemia (20/108; 18.5% versus 45/2804; 1.6%), prolonged labor (9/108; 8.3% versus 30/2804; 1.1%) and HIV (8/108; 7.4% versus 9/2804; 0.3%) as compared to self-referral also differed among associated conditions in women categorized as ‘necessary referrals’: anemia (20/108; 18.5% versus 45/2804; 1.6%), prolonged labor (9/108; 8.3% versus 30/2804; 1.1%) and HIV (8/108; 7.4% versus 9/2804; 0.3%).

Critical interventions among those women categorized as necessary referrals in the two groups were blood transfusion (32/108; 29.6% versus 20/2804; 0.7%) and laparotomy (29/108; 26.9% versus 4/2804; 0.1%) (Table 2).

4.4 Findings from cost-effectiveness analysis

4.4.1 Total costs incurred for ambulance and self-referrals

When computing for cost effective analysis, we considered potentially life-threatening condition and maternal near miss cases categorized as ‘necessary referral’ delivered in LCRH by either ambulance or self-referral. We excluded women identified with no complications categorized as ‘unnecessary referral’ from the analysis as these were women who should have received care at lower levels of care including health centers. Cost data was presented as unit costs for necessary referrals among women delivered by either ambulance or self-referrals. The unit cost per case was obtained by dividing total inpatient cost by the total number of admission days. Overall, the costs of operating ambulance services for women admitted with obstetric complications were $14,359 and medical costs incurred of $8294. While, for self-referrals the transport costs were $1,265 and medical costs of $16,322 as detailed in Table 3 and Table 4.

Table 4. **Cost of Ambulance services among obstetric cases delivered during 6-months period, LCRH, Bomet County**

Expenses	Cost per unit	Maternal near miss∝ N=32	Potentially life-threatening conditions∝ N=49	No complications∂ N=27
Car (Toyota land cruiser) [a] (*n*=3)	53,725	464	711	392
Lease agreement cost per ambulance which covers for; (*n*=3) *Fuel* *Car tax/insurance* *Car maintenance* *Damage repair* *Tyre repair/ substitution*	194/day	3,936	6,027	3,321
Driver's gross salaries (*n*=3)	340/month	227	348	192
Paramedic gross salaries (*n*=3)	340/month	227	348	192
Driver's allowances (*n*=36)	29/night	522	435	87
Paramedic's allowances (*n*=36)	29/night	522	435	87
Ambulance coordinator's allowance	145/month	32	49	27
Driver's airtime (*n*=3)	45/month	30	46	25
Total		5,960	8,399	4,323

Costs are expressed in USD, exchange rate of 1 USD = 103 Kenyan shillings

[a] Calculation of ambulance cost was based on the following; replacement cost ($53,725), useful life years (7), scrap value ($2,500), discount rate (3%) resulting into equivalent annual cost of one ambulance ($8,297). Therefore 3 ambulance costs incurred in 6 months were $12,446

∝ and ∂ represents necessary and unnecessary referrals

4.4.2 Total effects for ambulance and self-referrals

The assessment of effects was based on the life years gained for every woman categorized as necessary referral among ambulance and self-referrals. For each woman, the life years gained were discounted to 3% and 6 % using the formula = (1-e^(-r*LYsXi))/r) where e is function of exponential, r responds to 3% or 6% discount rate and LYsXi are the life years gained. The total life years gained were 1,657 years among 81 ambulance referrals when discounted to 3% and 6% were 1,217 years and 933 years, respectively. While, for self-referrals the total life years gained were 4,438 years among 239 women when discounted to 3% were 3,337 years and to 6% were 2,602 years.

4.4.3 Cost-effective analysis

When computing for cost effective analysis, we considered only 'necessary referrals' among women who had been delivered by either ambulance or self-referrals. First, we discounted costs and life years gained (LYG) by 3% for the proportion necessary referrals. The total costs incurred on ambulance referrals (transport + medical costs) were $22,143 a decrease of $665 against 1217 LYG. For self-referrals, the cost decreased by $512 while the LYG decreased by 1,101. The discount rates were further increased to 6%, there was decrease of $626 on ambulance referrals against 284 LYG. While self-referrals the cost decreased by $483 against 735 LYG. Finally, we assumed that if all necessary referral cases (*ambulance + self-referrals*) would have exclusively used ambulance services, then total intervention costs and LYG would be $90,112 and LYG 6095. This translates to an ICER of $14.8 per LYG, which is below the $30 WHO cost-effectiveness threshold. The studied intervention can therefore be considered as very cost-effective (Table.4).

Table 5. **Total and Incremental costs (US$, year 2019 values), Life years gained, CEA and Sensitivity Analysis among necessary referrals admitted at LCRH.**

Sensitivity Parameters	**Ambulance**		**Self-referral**		**Incremental**		**ICER**
Discounting	Costs	LYG	Costs	LYG	Costs	LYG	
3% discount	22143	1217	17075	3337	5068	-2120	- 2.4
0% discount	22808	1657	17587	4438	5221	-2781	- 1.9
6% discount	21517	933	16592	2602	4925	-1669	- 3.0
Effectiveness							
Ambulance only (75)	22808	1657	17587	4438	5221	-2781	- 1.9
Ambulance + self (85.3)	90112	6095	-	-	90112	6095	14.8
Ambulance + self (85.3)	-	-	23552	6095	-23552	-6095	3.9

Formula used to discount = (1-e^(-r*LYsXi))/r) where e is function of exponential, r responds to 3% or 6% discount rate and LYsXi are the life years gained for each mother.

4.5 Discussion of the results

Our main findings reveal that implementing an effective ambulance service for emergency obstetric care in Bomet County was highly cost-effective with $14.8 per life year gained, far below the $30 WHO cost-effectiveness threshold recommended by WHO (1996) and Lubell et al (2008). Furthermore, a sensitivity analyses was conducted for the rate of necessary referrals, ambulance costs and discount rate emphasized on the same conclusions, similarly to other studies conducted by Somigliana et al (2011) in Uganda, Tayler-Smith et al (2013) in Burundi, Tsegaye et al (2016) and Accorsi et al (2017) in Ethiopia who demonstrated the significance of effective ambulance transfer systems in emergency obstetric care in remote African settings.

Our ambulance obstetric transfer rate of 3.7% was lower than those reported from Ethiopia by Accorsi et al (2017) and Sultan et al (2018) as well from Uganda by de Ramirez et al (2014) who had reported rates between 5% and 66%. This could be explained by accompanying paramedics on ambulances providing support and triage of patients at the referring health facilities, preventing unnecessary referrals. Additionally, still one-quarter of women transferred by ambulance, were unnecessary referrals. These women could have been managed in sub-county hospitals and health centers without any use of ambulance services. Nonetheless, one in ten women who presented as self-referrals either from private clinics or home with severe maternal morbidities travelled to LCRH by public transport with not accompaniment by any medical professional exposing themselves to severe maternal outcomes *en* route.

This highlights the importance of implementing an ambulance obstetric referral protocol, educational interventions in health centers (*i.e* drills, simulations, continuing professional development), strengthening supervision in lower level health facilities, improving drug availability and equipping lower health facilities with drugs and essential supplies in order to prevent unnecessary inter-facility referrals which lead to increased workload in higher level facilities and avoidable costs for families and health systems as emphasized by Meredith et al (2013) and Newton et al (2015).

Main indications for ambulance transfer were prolonged labor and hypertensive disorders, comparable to other studies by Nkyekyer (2000) and Sultan et al (2018). This may be explained by poor quality of antenatal care leading to suboptimal knowledge of obstetric danger signs and low levels of birth preparedness and complication readiness (BP/CR) as reported by Kabakyenga et al (2011) and Smeele et al (2018). Health promotion regarding BP/CR at all stages of women's reproductive life with support from community members is needed. The other indication for referral was sepsis/peritonitis following cesarean section. This was also found elsewhere by Kalisa et al (2019), which could be explained by poor sterilization procedures and inappropriate use of antibiotics prescribed by inexperienced medical officers working in sub-county hospitals, which calls for strengthening of quality and continuum of obstetric care in those health facilities.

Our findings revealed that postpartum hemorrhage was the commonest potentially life-threatening complication, with one case of uterine rupture among women who had been admitted as self-referrals. This highlights challenges rural women encounter when seeking maternity care in LICs. Most women who had been transferred in critical conditions by ambulance, their referring health centers had called prior for ambulance services. This emphasizes the importance for implementation of the national health sector referral strategy guidelines.

There was no difference in terms of maternal morbidities between ambulance transfers and self-referrals which could be explained by: i) reduced transport delays, ii) improved clinical conditions upon arrival due to care by paramedics while on board, or iii) improved obstetric care after arrival in LCRH. Additionally, women who presented as self-referral came from less remote areas than those transferred by ambulance or more often from private clinics. Ambulance transfer thus improved survival of women coming from more remote areas who otherwise might have arrived in poorer condition.

Health centers notably used mobile phones to call for ambulance support, which is much cheaper than VHF radio communication reported in other studies by Somigliana et al (2011), Tayler-Smith (2013) and Tsegaye et al (2016). Thus, in LICs, Wu et al (2012) and Ruton et al

(2018) have advocated for nation-wide mobile phone coverage as they have been associated with significant reduction of maternal and neonatal deaths. While, Hofman et al (2008) suggested options like motorcycle ambulances based at health centers, as a cheaper alternative to car ambulances based at the district hospital. Unfortunately, this innovative transport approach by Hofman et al (2008) may not be replicated in every setting due to cultural acceptance issues.

Ambulance transfers were free of charge to parturient women delivered to LCRH. The costs were reimbursed by the county government of Bomet through a fixed lease agreement with Kenya's red cross society, not affected by increased number of referrals covered per day. There is a need to increase awareness on ambulance services through availing toll free numbers so that local people can call them directly as a more friendly and effective means of referral as compared to the current practice which increases uncomplicated births to LCRH.

CHAPTER FIVE: SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

This chapter presents summary, conclusions, and policy recommendations. Additionally, it covers study strength and limitations and future studies.

5.2 Summary and Conclusion

Our findings add importantly to the literature about the effectiveness of ambulance referral system from other rural remote setting, support the value of such interventions. We demonstrated that cost-effectiveness of ambulance services in our setting was very attractive. These can even be made more cost-effective when efforts are geared towards training educational interventions (*i.e* drills, simulations, continuing professional development) for health care providers, implementing an ambulance referral protocol, improving drug availability and equipping lower health facilities with drugs and essential supplies in order to prevent unnecessary inter-facility referrals.

The ambulance was mainly used to transport pregnant women from health centers to LCRH, and the main indications among ambulance and self-referrals were prolonged labor, hypertensive disorders and sepsis/peritonitis post cesarean section.

In our study, when ambulances were called upon. They were accompanied by paramedics who provided support and guidance to mothers while on board. Which could explain why there were no reported maternal death among women with severe maternal morbidities delivered by the ambulance to LCRH. Nonetheless, there were some women who presented as self-referrals either from private clinics or home with severe maternal morbidities travelling all the way to LCRH by public transport with not accompaniment by any medical professional exposing themselves to severe maternal outcomes *en* route.

5.3 Policy recommendations

Findings from our thesis suggest that efforts should be intensified at all levels to ensure quality of obstetric care and referral system to reach these targets. Thus, we call upon the following actors to address the following:

Community level at individual and family levels

- There is need to educate and sensitize women and their spouse about the importance of early initiation of antenatal care as well as completing the WHO recommended number of antenatal care visits.
- Women should be allowed to bring with them a family member or friend during labor, who can provide comfort and continuous support.
- Health promotion is much more needed on birth preparedness and complication readiness, at all stages of a woman's reproductive life.

At Provider level

- Implement a strong referral system and outreach program in sub-county hospitals and health centers to promote use of skilled birth attendance.
- The quality of antenatal care needs to be strengthened and should be able to detect complications such as hypertensive disorders during pregnancy. Women need to be better informed about obstetric danger signs, especially those related to hypertensive disorders and prolonged labor, and urged to seek health care promptly.
- Much as the ambulance services are free of charge, seems like local people are not aware based on the number of self-referrals admitted with severe maternal morbidities. Therefore, urgent need to create awareness about ambulance services, avail ambulance toll free call lines and allow the local people to call ambulance directly in case of urgent need.
- Need for refresher obstetric training through drills, simulations and continuous professional development for health care providers at health centers and sub-county hospitals so as provide quality obstetric care.

- Strengthen supportive supervision at lower health facilities, improve drug availability and equip those health facilities to prevent unnecessary inter-facility referrals.

At Policy level

- There is need to update and standardize referral guidelines to respond to the needs of poor populations at all levels.
- The county governments should engage non-governmental organizations and local stakeholders to take into consideration the ambulance services when planning for maternity care interventions.
- There is need to introduce eHealth strategies to ensure pregnant women are transported to health facilities in good time by ambulances provided by the counties.
- Implement audits into quality of care related to early detection of severe pre-eclampsia, eclampsia, postpartum infections, postpartum hemorrhage, sepsis, and referral patterns in Bomet county.
- There is need to advocate for nation-wide mobile phone coverage, strengthen where there is poor network coverage as well spread on installation where its non-existent to improve on referral system.

5.4 Study strength and limitations

5.4.1 Strength of the study

This was the first cost-effective analysis of a referral system comparing ambulance transfers and self-referrals among women admitted with obstetric complications in a rural hospital. We evaluated effectiveness using the adapted sub-Saharan African MNM criteria as a clinical judgement tool by Tura et al (2017) as compared to prior studies by Somigliana et al (2011), Tayler-Smith et al (2013) and Tsegaye et al (2016) who used theoretical judgment. All ambulances stationed in LCRH had accompanying paramedics who provided support and guidance to women while on board.

5.4.2 Limitation of the study

In terms of limitations, the retrospective nature of this study relied on routinely collected obstetric data, and bias may have occurred because of missing information in the obstetric charts. Our data was covered from women living in remote areas, which may render our recommendations ungeneralizable as compared to those in urban areas. Notably, we applied the national life expectancy tables without adjusting for pathologies and regions which may have led to *over*- or *under*-estimation of benefits. This was due to lack of available life expectancy tables for specific pathologies and regions for reference. Ambulance services themselves are not the only factor influencing referrals for skilled birth attendance. Other contributing factors are good mobile phone network coverage and cheap communication means. This study focused on maternal survival and not quality of life or disability which could have been relevant too. However, Wall (2006) and Glasier et al (2006) revealed how delayed cesarean section may impact of quality of life for women and their infant's through prevention of vesico-vaginal fistulae, infant disabilities and maternal death. Although ambulance services were meant for women with obstetrical complications, it is inevitable (and desirable!) that these were also used for other, non-obstetric referrals. For example, health centers or sub-county hospitals referred critically ill neonates or children or adults with severe anemia who required urgent blood transfusion. Those additional benefits were excluded from our analysis but arguably very important in prevention of related disabilities or mortalities.

5.5 Future studies

Notably from our findings there was poor use of ambulance services even after the latter being free of charge. Therefore, future studies to understand the facilitators and barriers (socio-demographic, psychosocial, financial, and cultural) that prevent pregnant women from appropriately accessing ambulance services in Bomet county. A comparative costing study from another county which uses their own ambulances, so we compare our study findings to choose the most cost effective.

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APPENDIX I: QUESTIONNAIRE

SECTION 1.0: SOCIODEMOGRAPHIC INFORMATION

Q. #	QUESTIONS	ALTERNATIVE RESPONSES	CODE	SKIP
1.1	What is your age?	_____ Year		
1.2	What is your current marital status?	1. Married/ in Union/ Co-habiting 2. Widowed 3. Divorced 4. Separated 5. Single		
1.3	To which religion do you belong?	1. Christians 2. Muslim 3. Other (specify)		
1.4	Where is your place of residence (constituency)?	1. Bomet Central 2. Bomet East 3. Chepalungu 4. Sotik 5. Konoin 6. Outside Bomet, Specify,……		
1.5	What is the highest educational level you completed?	1. None 2. Stopped in primary 3. Completed primary 4. Secondary lower and above		
1.6	What is your occupation?	1. None/Housewife 2. Informal employee 3. Formal/Salaried employee 4. Other (specify)…….		
1.7	Do you have medical insurance	1. None 2. NHIF 3. Other (specify)…….		
	If Married/ in Union/ Co-habiting			
1.8	Husband's age (years)	_____years.		
1.9	What is your husband's highest educational level completed?	1. None 2. Stopped in primary 3. Completed primary 4. Secondary and above		
1.10	What is your husband's current occupation?	1. None 2. Informal employee 3. Formal/Salaries employee 4. Private employee 5. Merchant 6. Other specify……		
1.11	Monthly income of your husband.	_____KES		
1.12	Family size	_____		
1.13	What is walking distance to nearby health facility (Kms)	1. ≤ 1 2. 1-5 3. ≥ 5		
1.14	Who advised you to seek care further during this pregnancy?	1. Self 2. Husband 3. Community health worker		

		4. Other(specify)_____		
1.15	What Mass media do you access in your house? (more than one option is possible)	1. Radio 2. Television 3. Other specify _____		
1.16	Does any member of your household have a Telephone/Mobile Phone?	1. Yes 2. No		
1.17	Which means did you use to call ambulance	1. Personal mobile 2. Health staff called 3. Others, Specify……..		
1.18	What type of transport means is commonly used in case of obstetric emergency in your community?	1. Public 2. Private 3. Motorbike 4. Walk 5. County ambulance		
1.19	In case there is no vehicle, what other means do expecting mothers use for timely referral in your community?	1. Walk 2. Motorbike/bicycle 3. Call for county ambulance 4. Others, Specify……..		

SECTION 2.0: OBSTETRIC CARE INFORMATION

Q. #	QUESTIONS	ALTERNATIVE RESPONSES	CODE	SKIP
2.1	What is maternal complication/ potentially life-threatening conditions	1. Severe postpartum hemorrhage 2. Eclampsia 3. Severe Pre-eclampsia 4. Puerperal sepsis 5. Ruptured uterus 6. Others, specify……		
2.2	What were the critical Intervention or intensive care admission done?	1. Use of blood transfusion 2. ICU admission or admission in recover room > 6 hours 3. Laparotomy 4. Admission to ICU 5. Others, specify……		

2.3	What were organ dysfunction/Life-threatening conditions?	1. Cardiovascular 2. Renal 3. Respiratory 4. Hepatic 5. Neurologic 6. Hematologic 7. Hysterectomy 8. Others……		
2.4	What was maternal outcome?	1. Live 2. Dead		
2.5	If maternal death, when?	1. During pregnancy or within 42 days of termination of pregnancy 2. After 42 days of termination of pregnancy		
2.6	If live, what was maternal	1. Date of Admission……, 2. Date of delivery or uterine evacuation 3. Date of hospital discharge or death		
2.7	Final mode of delivery or end of pregnancy, please specify?	1. Vaginal Delivery 2. Cesarean section 3. Complete abortion 4. Vacuum extraction 5. Laparotomy for ruptured uterus 6. Women still pregnant at hospital discharge or death 7. Laparotomy for ectopic pregnancy 8. Others, specify……..		
2.8	What was estimated gestational age completed (Weeks) at	1. Abortion/Marriage 2. Preterm 3. Full term		
2.9	What is infant outcome, please specify?	1. Live 2. Dead		
2.10	If infant death, please specify	1. Fresh stillbirth 2. Macerated stillbirth		
2.11	About conditions at the arrival in the facility and referral process, specify?	1. Yes 2. No		2.12 →
2.12	If yes, specify?	1. Delivery or abortion occurred before arrival at any health facility 2. Delivery or abortion with in 3 hours of arrival in the health facility 3. Laparotomy within 3 hours of hospital arrival or in other hospital 4. Woman referred from other health facility 5. Woman referred to any higher complexity hospital		
2.13	About the use of intervention, please state whether the woman received any of the following?	1. Yes 2. No		2.14.1-2.14.5 →
2.14.1	Prevention of postpartum hemorrhage	1. Oxytocin 2. Other uterotonic specify,……		

2.14.2	Treatment of postpartum hemorrhage	1. Oxytocin 2. Ergometrine 3. Misoprostol 4. Other uterotonics 5. Removal of retained products 6. Artery ligation 7. Hysterectomy 8. Abdominal packing		
2.14.3	Anticonvulsant	1. Magnesium sulphate 2. Other anticonvulsants		
2.14.4	Antibiotics	1. Prophylactic antibiotics during cesarean section 2. Parental, therapeutic antibiotics		
2.14.5	Fetal lung maturation	1. Corticosteroids		
2.15	What was the underlying cause of Near miss/death	1. Pregnancy with abortion/ectopic pregnancy 2. Obstetric hemorrhage 3. Pregnancy-related infection 4. Hypertensive disorders 5. Other obstetric disease/ complication 6. Medical/surgical/mental disease or complication 7. Unanticipated complications of management 8. Coincidental conditions 9. Unknown		
2.16	Contributing/ Associated conditions	1. Anemia 2. HIV infection 3. Previous caesarian section 4. Prolonged labor		
2.17	Effectiveness of ambulance referral (Categories)	1. Not effective 2. Possibly effective 3. Undoubtedly effective		
SECTION 3.0: COSTS OF THE AMBULANCE (Expenses)				
3.1	Transport			
3.1.1	Car (Toyota land cruiser)			
3.1.2	Car tax and Insurance			
3.1.3	Fuel			
3.1.4	Car Maintenance			
	Service			
	Damage repair			
	Tyre repair/Substitution			
3.1.5	Drivers gross salaries			
3.1.6	Accompanying paramedic- gross salaries			
3.1.7	Driver's uniform			
3.1.8	Accommodation for drivers			
3.2	Communication system			

3.2.1	Mobile phones			
3.2.2	Call costs (of health centers)			
3.2.3	Mobile phone costs (3 drivers)			
3.2.4	Call costs (3 drivers)			
SECTION 4.0: HEALTH ASSISTANCE COSTS				
4.1	Cost of Mode of delivery			
4.1.1	Normal vaginal			
4.1.2	Cesarean section			
4.1.3	Laparotomy			
4.1.4	Others, specify……..			
4.2	Treatment of complications			
4.2.1	Eclampsia			
4.2.2	Placental removal			
4.2.3	Second line uterotonic agents			
4.2.4	Fluids			
4.2.5	Parental antibiotics			
4.2.6	Others, specify……..			

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Thank you for your time.