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PORTABLE OBSTETRIC ULTRASOUND SERVICES AND MATERNAL HEALTH OUTCOMES AMONG RURAL WOMEN ATTENDING MALINDI SUB-COUNTY HOSPITAL, KILIFI COUNTY, KENYA

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DECLARATION

I hereby certify that the work embodied in this Thesis is the result of my original research and has not been submitted for a higher degree to any other University or Institution.

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APPROVAL

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ABBREVIATIONS AND ACRONYMS

ANC	–	Antenatal Care
CHP	–	Community Health Promoters
DOI	–	Diffusion of Innovation Theory
HBM	–	Health Belief Model
KHDS	–	Kenya Demographic and Health Survey
KIIs	–	Key informant interviews
MCH	–	Maternal and Child Health
MMR	–	Maternal Mortality Ratio
MOH	–	Ministry of Health
POCUS	–	Point-of-Care Ultrasound Services
SPSS	–	Statistical Packages for Social Sciences
UNFPA	–	United Nations Population Fund
WHO	–	World Health Organization
NACOSTI	–	National Commission for Science, Technology and Innovation

ABSTRACT

Maternal mortality remains a major development challenge in rural areas, where limited access to quality maternal healthcare and diagnostic services persists. Portable obstetric ultrasound can improve access by bringing essential diagnostics closer to underserved women. The study examined the relationship between portable obstetric ultrasound services and maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya. Specifically, the study assessed the influence of accessibility, quality of imaging and diagnosis, cost, and usability of portable obstetric ultrasound services on maternal health outcomes. The study was informed by Health Belief Model and Diffusion of Innovation Theory. A convergent parallel mixed-methods research design was adopted. Target population was 5,065 participants, from which a sample of 371 pregnant women was determined using Yamane's formula. Additionally, 10 healthcare providers and 15 community health promoters were purposively selected for qualitative inquiry. Data were collected using questionnaires and interview guides, with the instruments pilot-tested for reliability and validity. Quantitative data were analyzed using SPSS Version 27, while qualitative data were analyzed thematically. The findings revealed significant positive relationships between all four dimensions of portable obstetric ultrasound services and maternal health outcomes. Quality of imaging and diagnosis had the strongest correlation with maternal health outcomes ($r = 0.768$), followed by usability ($r = 0.739$), accessibility ($r = 0.701$), and cost ($r = 0.583$). Multiple linear regression showed that the model was statistically significant, $F(4, 360) = 243.781$, explaining 72.9% of the variation in maternal health outcomes ($R^2 = 0.729$). Quality of imaging and diagnosis was the strongest predictor ($\beta = 0.369$), followed by usability ($\beta = 0.318$), accessibility ($\beta = 0.261$), and cost ($\beta = 0.143$), all at $p < 0.001$.The study concludes that strengthening portable obstetric ultrasound services can improve maternal health outcomes, promote equitable access, and strengthen rural maternal healthcare delivery.

CHAPTER ONE

INTRODUCTION

This section lays forth the groundwork for the research. Emphasized is the motivation behind the study, the description of the problem, research goals, and research questions. Important concepts and operational definitions of the same are also given in this chapter, after which some of the constraints, scope and conceptual frameworks are presented.

1.1 Background to the Study

Maternal mortality rates have fallen dramatically in 20 years, but on a global scale maternal health remains one of the greatest public health and development challenges. Elci et al., (2025) indicates that the maternal mortality rate (MMR) in 2020 was 223 deaths per 100,000 live births, and about 95% of the world's 287,000 maternal deaths were in low and lower middle-income countries. Most maternal deaths are caused by avoidable complications that can be managed with timely diagnosis and excellent obstetric treatment, including hemorrhage; hypertension disorders; sepsis; obstructed labor and unsafe abortion (Antsaklis et al., 2020). This gap underscores the need to strengthen health systems and ensure provision of key maternal health services, particularly in rural areas which are less likely to be reached. To achieve SDG-3.1 - Reduce maternal mortality ratio (MMR) to less than 70 deaths/100 live births by 2030, strengthening uterine health services, improving access to skilled services, and for other interventions for women's health is required (Singh et al., 2025).

In most nations, obstetric ultrasound is an indispensable component of a pregnant woman's regular prenatal: consideration. It has a lot of applications including confirmation of the gestational age, baby viability, detection of multiple babies, detection of abnormalities, to assess the placenta location and the assessment of the baby's growth (Khalil et al., 2024). Although ultrasound testing is becoming more and more common to diagnose and monitor fetal health, a lot of underutilized areas have no regular ultrasound options.

The lack of trained personnel, expensive equipment, high operational costs and other factors have been attributed for this mainly, which further makes disparities in maternal health care. Point-of-care (POC) diagnostic imaging technologies are increasingly emerging and could reduce these limitations by offering the advantage of providing access to diagnostics in remote areas, like handheld obstetric ultrasound devices (Ranger et al., 2024). They are portable, cost effective, simple to use and deliver superior imaging solutions, making them suitable for primary health care environments. With these features, the potential to improve the services for mothers, reduce waiting time for diagnosis, and increase delivery of services to rural areas. Thus, mobile ultrasonography presents an opportunity to enhance rural populations' access to quality health care and to decrease geographical and health systems obstacles to vital maternal health treatments.

Portable obstetric ultrasound (POUS) has recently emerged in the industrialized countries as a key tool to improve maternal care and increase affordability and accessibility of prompt diagnostic imaging, and facilitate clinical decision-making throughout pregnancy (Easter et al., 2023). The need of early identification and management for obstetric problems is shown by the fact that the maternal mortality rate in the US increased from 20.1 per 100,000 live births in 2019 to 32.9 in 2021 (Kim et al., 2024). In emergency situations, and in rural contexts, portable point-of-care ultrasonography is a key component of obstetric care and makes rapid identification of ectopic pregnancy, fetal growth restriction, atypical fetal presentation and placental abnormalities possible.

Plöger et al. (2024) concluded that there is significant progress on both timely clinical decisions and referrals, as well as diagnostic results achieved using handheld ultrasound, with results similar to conventional ultrasound. Additionally, there is almost perfect agreement for estimated fetal weight. Their effectiveness depends on the skills of the healthcare workers in interpreting pictures, quality assurance techniques, and continuing education activities.

This emphasises the importance of the abilities of the health system, provision of high quality services, provision of prompt diagnosis and treatment as well as making portable ultrasonography available.

Even though there has been some progress over the last few years, India still faces a significant challenge in maternal health, with the maternal mortality ratio of 97 per 100,000 live births in 2018–2020 still lower than what was seen in 2014–2016 (Bakshi et al., 2025). Portable obstetric ultrasonography has been adopted into community maternal health programs and mobile outreach activities, which has helped to enhance access to prenatal diagnostic services in remote areas. Technology has improved the referral system for specialist obstetric care, increased the consumption of prenatal care services, and allowed for the early diagnosis of high-risk pregnancies, according to a research by Bahadur et al., 2025.

Health system capacity is still an important determinant in better maternal health outcomes, but there are still obstacles to its optimal utilization, such as cost, a lack of skilled personnel, equipment maintenance, and regulatory monitoring.

Although Sub-Saharan Africa (SSA) has economies making substantial investments in reproductive and maternal health through member country programs, it still has the highest maternal mortality rate in the world, with approximately 70% of maternal deaths occurring here (Barrow et al., 2026). Nigeria, another all-time leader in maternal deaths, is now introducing portable obstetric ultrasounds in its poorly served villages and towns to boost maternal health care services. Dowdy et al. (2025) states that the maternal mortality ratio for the country is 1047 deaths per 100,000 live births. To address this, the government has developed portable ultrasonography for the early diagnosis of obstetric problems, referrals of high-risk pregnancies and as a clinical decision tool. When a mobile obstetric ultrasound machine was introduced the use of prenatal diagnostic services increased and primary health care referral pathways were strengthened (Luntsi et al., 2021).

However, in many rural areas, sustainability and effectiveness of portable medical ultrasound is still hindered by factors such as lack of training in healthcare workers, lack of availability of electricity, maintenance of equipment, and financial constraints.

Although the reproductive, maternal, infant, child and adolescent health care has been fully funded from time-to-time, it has done little to cure severe maternal health issues in Kenya. Okoth et al. (2023) reported that women residing in rural areas face greater challenges in accessing quality pre-natal care and diagnostic services, and significant variations in maternal healthcare utilization by urban and rural residents were found. While it is recommended by national policies to perform routine obstetric ultrasounds during pregnancy in order to detect complications early on, women who go to lower-level public facilities often do not have access to these services, according to Githemo et al. (2025). Even though obstetric sonography, particularly, is an underutilised tool, several logistical hindrances can be identified, including limited access to trained sonographers, suboptimal diagnostic equipment and equipment availability, high travel costs, and co-pays by the patient especially in remote locations (Rhodes et al., 2024). Primary health care providers must have portable obstetric ultrasonography services to address the challenges associated with delayed referral, poor maternal health outcomes and/or delayed detection of obstetric concerns.

Enabling maternal health care remains crucial in Kilifi County due to the county's demographic features of a rural majority, diffuse distribution of residents and a lack of centralised health care facilities (Kahindi et al., 2024). There is no availability for ultrasound services outside the urban institution, and the county has tried to invest in services for reproductive health to help maternal health services but has not led to more diagnostic imagings. This means women living in rural areas may experience delayed access to maternal health care, higher health care costs, fewer providers of maternal health services and fewer health care providers trained to provide obstetric services to women living in remote areas (Maina, 2024).

Malindi Sub-County Hospital, which serves the remote population in Kilifi County, is a key public facility offering the whole range of care in relation to reproduction including ante, neo, EOC and post-natal services (Kahindi et al., 2024). It may be challenging to make a proper obstetric assessment at the right time as pregnant women from a large number of outlying health centres, which have no proper diagnostic imaging facilities, come to the hospital. It's fair to say that the facility's capacity to deliver a portable obstetric ultrasound screening service will lead to better maternal outcomes, a greater number of women made available to a diagnostic ultrasound service, better obstetric diagnosis, lower cost of obstetric ultrasound screening, more useful obstetric ultrasound screening in routine antenatal care, etc. in rural communities.

Although for many areas portable obstetric ultrasound (pousun) is already effective, it remains that there are still some large blanks in our knowledge of how beneficial pousun can be. Studies on this portable ultrasound are mostly focused on technical performance of the ultrasound, diagnostic accuracy, ease of use and healthcare workers experiences (Koech et al., 2022; Wanjiku et al., 2024). Limited information exists on how the experiences of rural Kenyan women with public health care services influence their maternal health outcomes, which can vary based on attributes such as accessibility, diagnostic accuracy, cost, and utilization of portable obstetric ultrasound services. In addition, linkages were not well understood between Malindi Sub County Hospital and the hospital playing its vital role of delivering maternal health services to the rural residents in Kilifi County. This knowledge gap had a tremendous influence in the development of policies and investments to improve maternal health care production where portable obstetric ultrasonograph was utilized in low-resource areas.

1.2 Statement of the Problem

All pregnant women should be able to access quality antenatal care (ANC) services in a timely fashion, with a particular focus on obstetric ultrasonography services, to ensure that maternal health is improved and ensure early diagnosis and treatment of issues pertaining to pregnancy. In order to precisely date the pregnancy, check for fetal anomalies and multiple pregnancies, and guide appropriate obstetric treatment, St-Onge Ahmad (2023) recommends that all pregnant women get at least one obstetric ultrasound scan before 24 weeks gestation. In the same way, SDG 3.1 is to bring the maternal mortality ratio down to less than 70 deaths per 100,000 live births by 2030. Improved access to excellent maternal health and care services is a key indicator identified by the United Nations (2024) that is critical to achieving this goal.

However limited access to obstetric ultrasonography services is still available to most of pregnant women in rural areas therefore the optimum has not yet been reached in malindi sub-county. Asiimwe et al. (2024) pointed out, there are still substantial gaps in the quality of prenatal care between rural and urban parts of Kenya. Even today, many public health institutions continue to find it difficult to deliver maternal health services due to limited skilled staffing, diagnostic facilities, as well as ultrasound machines (Ministry of Health, 2024). The all too frequent result of these challenges is a delayed diagnosis of pregnancy complications, prolonged delays in referral to a specialist and sub-standard maternal health results, especially among women in rural areas.

The lack of prenatal diagnostic services has been a problem in times of scarce resources, but portable obstetric ultrasonography might offer a solution. Shaddock and Smith (2022) showed that portable ultrasound could benefit both referral and clinical decision making at the point of care in rural health facilities, and Chapman et al. (2025) demonstrated that it could aid in early detection of complications of pregnancy and can help increase utilization of point of care ultrasound.

Past research has been limited in the consideration of the practicality and diagnostic usefulness of portable ultrasonography, with less attention on the determinants of the quality of maternal health outcomes in rural Kenya, such as the cost, ease of use, accessibility, and imaging or diagnostic quality. Even though the Malindi Sub-County Hospital plays an important role in provision of maternity health care services in Kilifi County, there have been no empirical studies of these linkages among obstetric women accessing this health institution. This study aimed at exploring the influence of mobile obstetric ultrasound on the health of antenatal women of rural Malindi Sub-County Hospital in Kilifi County, Kenya.

1.3 General Objective

With the goal of learning how rural Kenyan women who visit Malindi Sub-County Hospital for their pregnancies fare in terms of maternal health and the availability of portable obstetric ultrasonography services.

1.3.1 Specific Objectives

This research is specifically based on the above mentioned aims.

i. To assess the influence of the accessibility of portable obstetric ultrasound services on maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya.
ii. To examine the influence of the quality of portable obstetric ultrasound imaging and diagnostic services on maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya.
iii. To determine the influence of the cost of portable obstetric ultrasound services on maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya.

iv. To examine the influence of the usability of portable obstetric ultrasound services on maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya.

1.4 Research Questions

This study was guided by these research questions

i. How does the accessibility of portable obstetric ultrasound services influence maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya?

ii. How does the quality of portable obstetric ultrasound imaging and diagnostic services influence maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya?

iii. How does the cost of portable obstetric ultrasound services influence maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya?

iv. How does the usability of portable obstetric ultrasound services influence maternal health outcomes among rural women attending Malindi Sub-County Hospital, Kilifi County, Kenya?

1.5 Justification of the Study

Maternal deaths and morbidity are a significant public health and development problem, especially in rural areas where it was observed there was poor access to ANC services of good quality and in time. Failure to diagnose and treat pregnancy complications like multiple pregnancies, placenta previa, fetal abnormalities and pre-eclampsia are related to adverse maternal outcomes. These issues do not only exist at the clinical level but also at the level of broader development issues as well including inequities in access to health care, poor health infrastructure, poor diagnostic capabilities and geographical inequalities.

Portable obstetric ultrasonography equipment has four primary features: accessibility, user-friendly, affordability and diagnostic value. Portable ultrasound can help overcome barriers of service delivery and geography as well as help improve equality in maternal health care delivery in rural areas. By enabling potentially high-risk conditions to be identified earlier, this technology can target the correct provider to patients and intervene where appropriate.

Unfortunately, there has been a lack of study on what works and what does not work, in the context of rural communities in Kenya such as Malindi Sub-County, to improve women's and family health through these programmes. This suggests that, to make any claims about how portable obstetric ultrasound contributes to improved access to maternal healthcare, equitable service delivery and overall improvements in women's health in rural areas, data from the local context is needed. The technological capacity of the health system to provide health services is shaped by factors internal to it, including the number and quality of health professionals available to provide care, the cost and quality of the equipment available, the reliance on repairs, the fit of the system with practices for prenatal care and referral; hence, it is important to assess the capacity of the system. The aim of this study is to gain insight into the potential benefits of such clinical technology to enhance services in peripheral regions and the possibility of it reducing inequities in maternal health care access.

The research is needed at this moment, especially as Kenya's attention has gone to attaining Universal Health Coverage (UHC) and eliminating finance and other barriers to access to good health care for everyone, regardless of their geographical location or socio-economic class. The research falls under Sustainable Development Goal (SDG) 3 which aims to reduce the worldwide maternal mortality ratio to under 70 deaths per 100,000 live births, by 2030 (United Nations, 2020). This study aims to look at the links between mobile obstetric ultrasound and the health outcomes for mothers residing in rural areas and is therefore context specific while advancing the national and international development goals.

The research may have implications in terms of policy, development and application. The first use of findings is to inform the design and delivery of health technology and its deployment strategies by identifying key features of portable ultrasound that are readily associated with better maternal health outcomes—including accessibility, imaging quality, and affordability and how simple it is to use. More significantly, second, policymakers at the federal, state, and regional levels can use the findings to help guide the design of specific activities to improve access to prenatal care in rural areas. It may involve attracting and retaining skilled health care providers, integrating portable ultrasound into routine maternal health services and making better referrals. Third, official, non-governmental organisations (NGOs), development partners (DPOs) and county health management teams (HMSs) can draw on the study as a source of evidence to inform prioritisation of ‘priorities'. In this way, they will have better access to critical inputs and prioritize their scarce resources to support interventions that enhance access and equity and strengthen service delivery in poorly served rural communities and ensure maternal health outcomes are improved. Contributing to the Development Studies research, the research offers evidence of the potentials of health technology addressing the health disparity issues in rural areas, strengthening health system locally and offering the equal access to maternal health care.

1.6 Significance of the Study

This research is addressing a critical need in the delivery of maternal health services in places such as Kilifi County where access to diagnostics tools such as ultrasound is limited. Improving prenatal care in underprivileged and rural areas is possible because to the study's findings on the connections between POU services and mother outcomes. If the findings can support physicians in achieving a more accurate diagnosis of a woman's health status, provide more prompt treatment to high-risk pregnancies, and effectively refer women with more complex needs, improved maternal health outcomes may be realized. Developing the diagnostic tools,

if available on a wide scale, could contribute to improve service delivery to women in the rural areas and reduce disparities related to geographical distances.

The study offers valuable information on a national and local level which could inform health policy and resource allocation. For example, in under-resourced and underserved areas, it is useful to understand how new technology (e.g., portable US) fits in with existing maternal health programs. The findings in this study have important implications for policymakers, county health management teams, healthcare providers, development partners and NGO representatives on healthcare workforce training, distribution of resources, adoption of technologies, and improvement of maternal health care service delivery in rural areas.

The research will not only be used to guide local policy decisions regarding inequities in health access but also to the broader goal of health technology development of eliminating health access inequities. This research explores portable obstetric ultrasound in rural health service and its findings suggest that obstetric ultrasound decreases maternal health risks, builds health systems, and gives access to healthcare to everyone. It contributes to Sustainable Development Goal 3, ensuring that all people can live a healthy life and promoting their well-being, and can also help reduce maternal mortality.

1.7 Scope and delimitation of the Study

This research was conducted to determine the association between existence of portable obstetric ultrasound services and maternal health outcome for rural women who attend Malindi Sub-County Hospital in Kilifi County. Accessibility, imaging and diagnostic quality, usability, and affordability were the four main areas of portable obstetric ultrasonography that were investigated. The four variables used are directly related to the services available for ultrasonography for detection of pregnancy related issues and the urgency with which measures are taken to improve maternal health. Instead of focusing on improvements in health worker

training, policy enforcement, or infrastructure, the focus was on facility-level actionable variables, related to treatment delivery. We got rid of these factors.

In this research, both quantitative and qualitative approach were used. standardized questionnaires were used to interview healthcare providers and community health promoters providing or supporting sonography functions and for pregnant women of reproductive age (15-49) accessing and receiving antenatal care services. The research was done for period of 3 months in order to collect, validate and give preliminary analysis of the data.

Malindi Sub-County hospital was chosen for the research purposes due to its prominent role of serving as a referral hospital to the rural communities surrounding it. The facility offers In Patient Prenatal Care, Mobile Obstetric U/S services. It is thus an appropriate setting to examine the relationship between health of mothers in rural Kenya and having access to ultrasound services.

The study was based on Malindi Sub-County Hospital and its periphery villages, therefore results might not be applicable to other counties, cities or other healthcare institutions as a result of different demography, resources and policies. These four variables were chosen because of their association with the goals of the study—that is, modification of these variables would make a difference in maternal health outcomes—sneden's comment on the "study as a shape" of variables, and to reduce the number of potentially confounding variables. Also, the study didn't include women who were pregnant, but not attending programs, or receiving pregnancy care from other providers; it only included pregnant women attending programs, along with the necessary healthcare providers and community health advocates.

1.8 Limitations of the Study

Subjects of this study were women who visited Malindi Sub-County Hospital, in rural areas. Due to the variations in socioeconomic status, culture and health-care providers, the results may not be relevant to other hospital or area. Explicit information about the environment in which the study took place, and to whom, was provided to address this restriction. This allowed readers to understand the results in context and make comparisons with other rural healthcare settings that are comparable.

Portable obstetric ultrasonography services are part of the factors used to determine maternal health outcomes, which include other measures to improve mother health, the availability of qualified health professionals and referral networks. These factors may influence the relationship between portable obstetric ultrasound and mothers' outcomes. These have been minimised by applying the standardised data collection technology and statistical analysis to examine the relationship between these components and maternal health outcomes, and by narrowing down the priority components to mobile obstetric ultrasonography services. This approach ensured a more credible and legitimate study, and it could include other contextual factors that might impact maternal health outcomes.

The limited nature of the study in terms of data collected from Malindi Sub-County Hospital limits the generalisations that can be made to areas outside of the Sub-County, particularly to those with very different cultural values, economic status and health services.

Healthcare access may be less or the patient population may be different in rural areas and as a result, the influence of the portable ultrasound services could be different. Some programs affect maternal health outcomes concurrently and were not included in this research, such as concurrent maternal health programs, changes in the economy or other treatments for health that are available to mothers. These consequences of portable ultrasound services may be hard to separate from the data, which might lead to less reliable results.

1.10 Conceptual Framework

The dependent variables are maternal health outcomes, which provide evidence of the efficacy of portable ultrasound in improving both maternal and fetal health as the independent variables are cost, usability, quality of imaging and diagnostics, accessibility of portable ultrasounds, and accessibility of portable ultrasounds. Both sociocultural and geographical factors influence the effect of portable ultrasonography on maternity health outcomes.

The theory behind this is that, there may be a significant relationship between the health of mothers and the provision of medical technology, in this instance portable ultrasonic medical equipment. Four key factors that the framework puts forward influence early identification of pregnancy-related issues and the quality of mother's health: accessibility, imaging/diagnostics quality, usability, and cost. For pregnant women and their health care practitioners, portable ultrasound devices should be readily available and easy to use. Accessibility is linked to more and higher quality prenatal care.

Quality imaging and diagnostics are vital in the early intervention to enable the doctor to have all the information needed in order to make decisions for pregnancy care. Usability is a critical factor to take into account, particularly when the healthcare practitioner operates such a device in a remote or low resource setting with limited training opportunity. To whether the technology can be adopted and used or not, the affordability of the technology affects pregnant women and healthcare system. All these can be determinants that will affect maternal health outcomes as a dependent variable. The concept, predicated on the premise that portable ultrasound devices would be more easily available and utilized, would help to reduce challenges for mothers and newborns by improving prenatal care through early diagnosis and prompt intervention.

The working premise of this framework is based off of health systems and access theories to assume that cheap, readily-available advancements in health technology can improve the health of people. With these factors optimized, the effect of portable ultrasound will be more evident.

Independent variables

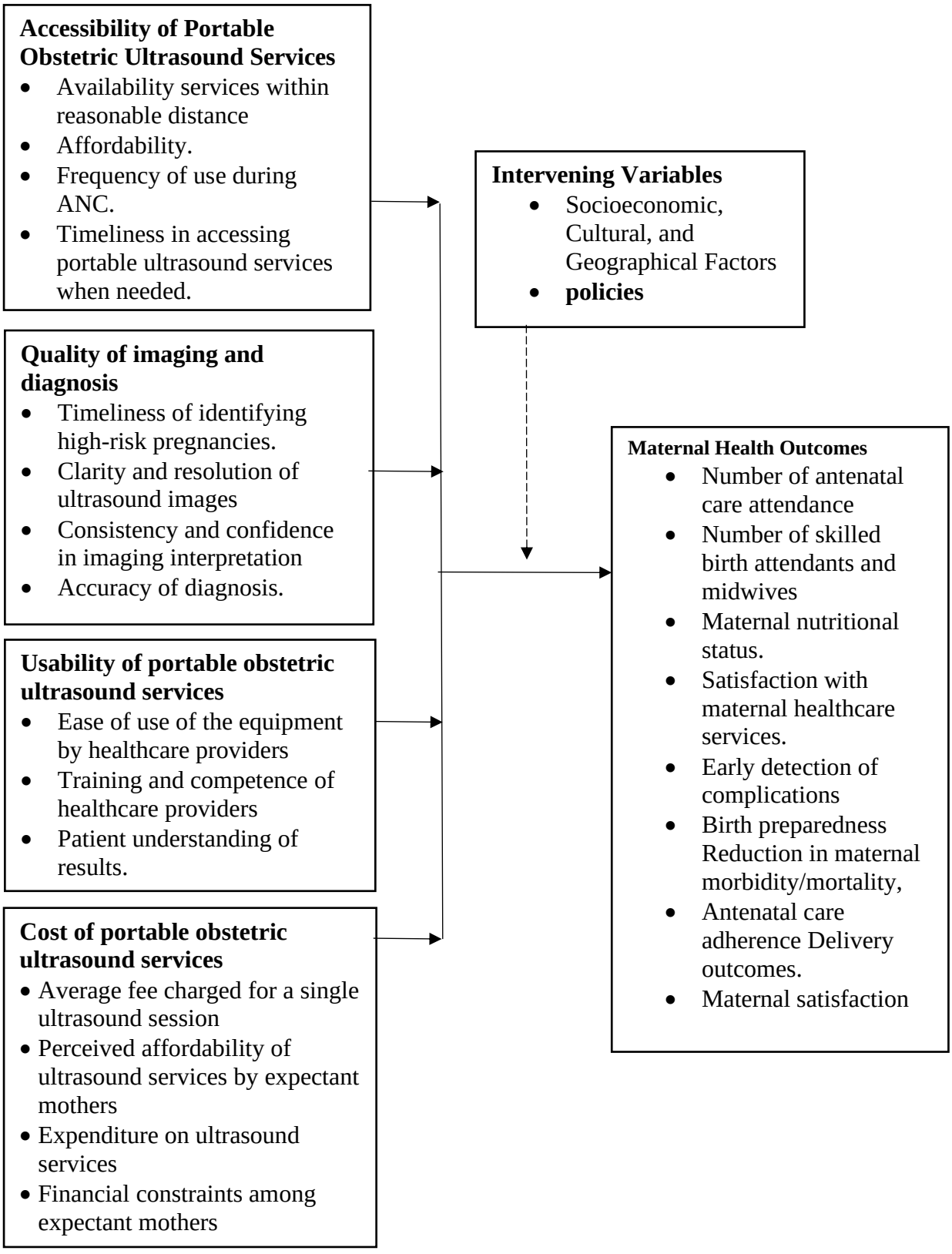


Figure 1: Conceptual Framework

1.11 Operational Definition of Variables

Accessibility of Portable Obstetric Ultrasound Services: The degree to which pregnant women can physically access and utilize portable ultrasound devices, measured by the number of functional devices available per facility, frequency of use, and distance to nearest facility with a portable ultrasound.

Cost of portable obstetric ultrasound services: The financial burden associated with accessing portable ultrasound services, including device cost, maintenance expenses, and out-of-pocket costs to patients, measured in local currency and reported by health facility records and patient surveys.

Maternal Health Outcomes: The health status of pregnant women as influenced by prenatal care, assessed through rates of early detection of pregnancy complications, referral rates, maternal morbidity/mortality statistics, and satisfaction with prenatal care services.

Portable obstetric ultrasound services: The use of handheld or portable ultrasound devices to provide obstetric imaging during antenatal care. In this study, the variable is measured using four dimensions: accessibility, quality of imaging and diagnostics, cost, and usability of the services among rural women attending Malindi Sub-County Hospital.

Quality of Imaging and Diagnostics: The clarity, accuracy, and reliability of ultrasound images and diagnostic interpretations, assessed through healthcare provider satisfaction surveys, diagnostic accuracy rates, and equipment specifications (e.g., resolution quality).

Usability of portable obstetric ultrasound services: The ease with which healthcare workers can operate the portable ultrasound machines, measured by training hours needed, number of user errors, and user satisfaction scores collected through a structured guided interview.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section reviews the theoretical and empirical literature related to maternal health outcomes, quality of diagnostics, cost, and utilization of portable obstetric ultrasonography services to identify what is known and what needs to be explored.

2.1 Theoretical Framework

Theories underpinning the research were the Theory of Diffusion of Innovations (DOI) and the Health Belief Model (HBM) which are competing theories. The HBM focuses on the factors affecting the implementation of portable obstetric ultrasound technologies and providers' uptake of this practice in routine maternal care, with pregnant women's perceptions of risk, benefit and barrier being the factors that affect their uptake of the service. Theories were not used alone and not three theories were used at all; rather, a balance was used by incorporating HBM and DOI in the explanation of the acceptance of new technology and seeking out medical attention. They complement each other and can be utilized collectively for systematic study on the impact of obstetric ultrasonography mobile services on maternal health in remote areas.

2.1.1 Health Belief Model

In the 1950s, Rosenstock and Hochbaum developed the Health Belief Model and Rosenstock subsequently modified it (1974) to identify the effect that attitudes have on behaviours, regarding seeking health care. The model suggests that in order to adopt a health promoting behavior, individuals would need to have the following beliefs: the health condition is serious; adopting preventive action is beneficial for them; there are few barriers to adopting the behavior; they will be given cues to act; and they have confidence that they will actually be able to carry out the behavior-changing action (Champion & Skinner, 2008). This notion has

been explored in various studies in the realm of maternal health and as a way of conceptualizing prenatal health and preventative care.

The Health Belief Model is likely a good explanation for the use of portable obstetric ultrasound amongst pregnant women. Champion and Skinner (2008) reported that perceptions of barriers have a significant impact on people's intentions to access healthcare. This research is an attempt to test the hypothesis that if prenatal care services was more readily available in the form of portable obstetric ultrasound services, the barriers of being far away, waiting for an appointment or not having any diagnostic services would decrease the likelihood of pregnant women utilizing these services. Also, more pregnant women will be able to affordably access vital prenatal diagnostic services like ultrasounds because to the declining cost of mobile ultrasounds.

The idea then extends to the notion that if there are major gains to be witnessed from taking good health action people are likely to take it. This study shows that women trust you more to make decisions on their health and act quickly to address challenges affecting their pregnancy when you have access to quality imaging and information. Obstetric ultrasonography is an essential element of prenatal treatment, according to Khalil et al., (2024), as it enables a precise assessment of the stage of pregnancy, the development of the fetus, the positioning of the placenta and the occurrence of malformations and deformities. In addition, Bandura (1997) suggests and adds to the Health Belief Model that the ease of use of the portable ultrasound services increases a pregnant woman's self-efficacy, which in turn, leads to her confidence to use the equipment. In addition, expecting mothers might be motivated to keep their prenatal appointments and listen to their doctors' recommendations by seeing real-time photographs of their fetuses, according to research by Gashaw et al. (2025).

Based on the Health Belief Model, the study found that factors such as perceived accessibility, affordability, reliability and ease of use of early diagnosis and timely management of

pregnancy-related complications through portable obstetric ultrasound services are important factors in determining pregnant women's utilization of these services. This, in turn, results in improved outcomes for mothers' health. The theory does not consider many of the bigger health system characteristics, such as socio-cultural factors, limited infrastructure and lack of trained health professionals, that influence costs of care in rural areas, including Malindi Sub-County. However, the model provides a good theoretical framework to explain how the research variables affect outcomes in maternal health.

2.1.2 Diffusion of Innovation Theory

A theory that Everett Rogers created in 1962 and later refined by Rogers (2003) to explain how new ideas, technology, and practices permeate social systems is known as the Diffusion of Innovation (DOI) Theory. According to the idea, the relative advantage, compatibility, complexity, trialability, and observability are the most important factors to better understand for an innovation to be adopted. Innovations will more likely be adopted if they are more advantageous than existing methods, they meet the users' needs, they are simple to use, and they can be evaluated and monitored (Rogers 2003). The idea also underscores the influences of time, social systems and communication channels on the rate and extent to which innovation is adopted.

Because it delves further into the elements that impact healthcare professionals' and pregnant women's adoption and use of portable obstetric ultrasonography services, the Diffusion of Innovation Theory is applicable to this research. Omnivores, which are innovations that offer more significant benefits, are more widely accepted and adopted more quickly than lambs, which offer less significant benefits (Rogers, 2003). Portable obstetric ultrasound equipment provides an alternative to traditional ultrasound services that can reach underserved areas in rural areas to increase access to prenatal imaging – which can be helpful. Their mobility, ease of use, and ability to be integrated into normal antenatal care services encourage integration

into maternal system. They also offer a referral service that provides them with the chance to use primary health care facilities.

Moreover, the notion suggests that the acceptance of health care advancements will be influenced by communication and trusted opinion leaders. It can be useful to talk to local community health opinion makers, prenatal clinics, and healthcare providers to promote use of MOUS services and awareness in Malindi Sub-County. As pointed out by Greenhalgh et al. (2004), healthcare innovations are more likely to be accepted and used if they are able to be transferred via current health systems. Further, in low-resource environment, Geldsetzer et al. (2021) found community marketing of new healthcare technology plays a significant role in its adoption.

The theory provides a way to explain the variables used in the study and the connection between those variables and mother's health outcome as well. With the advancements in imaging and diagnostics, pregnant women will have increased faith in their healthcare professionals' abilities to spot problems early on, and they will have easier access to ultrasound services due to decreased costs. Timely diagnosis, proper referral, and improved obstetric treatment may be achieved by the widespread use of portable obstetric ultrasonography provided it is easily available and simple to use. Use of portable diagnostic technology can help children be diagnosed early, therefore receiving timely clinical care and enhances maternal health care, as stated by Greenwood et al. (2020).

While it pays attention to the nature of the invention and also the actions of adopters, the Diffusion of invention Theory offers some explanation of exactly why portable obstetric ultrasonography services are extremely popular. However, more contextual factors that could affect the dissemination of health care innovations are not included in the theory (Dearing, 2009). These include: infrastructure, policy environment, personnel shortages and health system capacity. The rural Malindi Sub-County is especially impacted by these restrictions

thanks to its low level of infrastructure and lack of trained medical specialists who may contribute to the low uptake of the portable obstetric ultrasonography equipment. However, the theory is still applicable when trying to understand factors that affect the uptake of portable ultrasound services such as accessibility, affordability, usability, imaging and diagnostic quality all of which can lead to better women's health outcomes.

2.2 Review of Empirical Studies

It offers a short overview on some of the cross-sectional observations and reviews outcomes from initial clinical trials to understand how adding POU services affects accessibility, imaging quality and diagnosis, cost, and optimizing services from a global, subnational, and county perspective. This was a detailed study into the impact of portable ultrasound at different situations on the maternal health.

2.2.1 Accessibility of Portable Obstetric Ultrasound Services on Maternal Health Outcomes

Therefore, Obstetric ultrasonography services are crucial for maternal health, enabling timely referrals, adequate clinical care and early identification of pregnancy-related issues. To maximize pregnancy monitoring capabilities, World Health Organization (2022) recommends all pregnant women to receive a scan before 24 weeks, for proper assessment of gestational age, detection of fetal abnormalities, and for early interventional obstetric treatments. But it is still difficult in many low-resource and rural areas to find the ultrasonography because of geographical restrictions, the low availability of health facilities and needed health workers.

An American study by Kim et al., (2021) regarding the utilization of portable obstetric ultrasound in rural health care settings showed that more access led to improvements in clinical decision-making during antenatal care, fewer delays in referral and more early detection of pregnancy complications. The study noted that adoption of the portable ultrasound equipment in primary care enhanced the system of providing maternity health care, especially in poor and

underprivileged zones. The study may not have appropriately reflected the resource-poor rural health care environment in Kenya due to the environment in which it took place, an environment with advanced diagnostic facilities and a relatively well resourced health care system.

Moreover, Yadav et al. (2020) found that in rural India, pregnant women were deprived of obstetric ultrasonography service and it gave rise to complications in maternal health and late diagnosis of pregnancy related problems. The use of portable ultrasound in basic healthcare centers helped to improve early detection and referral system of high-risk pregnancies. However, this study was conducted within the context of the Indian health care system and not under the conditions of the Kenyan system, where the implementation of policy and the allocation of health resources are different from that of India.

Stewart, et al., (2021) have conducted a study in rural Tanzania to assess the effect portable ultrasound programs have on increasing ANC usage and early referral of women with high-risk pregnancies. From the results, it was found that women who had access to ultrasound had more uptake of ANC and better early referral rates. The results of the study indicated that those who had better access to obstetric care utilized it more and problems were more likely to be diagnosed sooner when access was better. Rural areas were still facing challenges for bringing equipable ultrasonography services to an equal level through the absence of infrastructure, trained personnel and energy provision.

Since obstetric ultrasound services were mostly offered at higher level referral clinics in Kenya, Onsongo et al. (2025) looked at the distance that pregnant women had to travel to get them. Long travel times to medical centers were related with postponed prenatal care, including ultrasounds, doctor visits, and the identification of problems. To make them more accessible, it proposed to move the ultrasound services to lower level medical centers. Although

geographical access was considered, the research did not examine the impact of the provision of portable obstetric ultrasonography services to the health of rural women.

The studies analyzed indicated that readily available portable obstetric ultrasonography services are beneficial for early detection of pregnancy issues, for a prompt referral, and for use of maternal healthcare. However, most of published studies have ignored the effect of the accessibility of portable obstetric ultrasound services on maternal health outcome of rural women attending Malindi Sub-County Hospital and instead studied the accessibility of Ultrasound services, or the experience of implementing ultrasound services in general.

2.2.2 Quality of Imaging and Diagnosis on Early Detection of High-Risk Pregnancies

The quality of imaging and diagnostics offered by portable obstetric ultrasonography services directly influences the accuracy of pregnancy-related problems identified, guidance of prompt clinical decision-making, and improvement of maternal health outcomes.

Liu et al. (2021) conducted a study on portable obstetric ultrasonography in China, and its application to enhance maternal health care in rural health institutions. A cross sectional study was performed to include pregnant women and their health workers using portable ultrasonography services. The research found that ultrasound and magnetic resonance imaging (MRI) provided high quality imaging, which helped in the early identification of placenta previa, congenital defect, fetal malpresentation, and multiple pregnancy and provided immediate referral for clinical decision-making. The authors recommended two methods for maintaining a high quality portable ultrasound: maintaining them consistently and continuing education of the healthcare professionals. The study, however, did not look at the impact of improved imaging and diagnoses on maternal health results, something the present study is interested in exploring due to its focus on portable ultrasound program implementation.

In the current literature, the specificity and sensitivity of a portable ultrasound device for obstetric diagnostics were assessed by Maraci et al. (2022) by means of a literature study. The

evaluation found that portable ultrasonic devices which have high resolution imaging are just as accurate as conventional devices when used for normal obstetric use. The authors promoted the use of portable ultrasonography and competence testing of medical professionals as part of routine prenatal care. However, in both cases the study was conducted in affluent countries having well-developed health care systems; the results may not be transferable to Kenya's rural health provision, and other low-income countries.

A study by Hall et al (2021) used a mixed methods approach to investigate the implementation of point-of-care obstetric ultrasonography services in basic healthcare facilities in rural Tanzania with healthcare providers and pregnant women. The findings indicated that the quality of diagnostic images influenced positively referral systems, early risk pregnancy identification as well as mothers' health care service delivery. It was suggested to include lower level health institutions in portable ultrasound expansion work-ups, technical assistance provision and training of health professionals. The study did not focus on how pregnant women's quality of an image relates to their maternal health conditions; rather, it focused on the implementation of the program.

In order to determine what variables influence healthcare professionals' use of obstetric ultrasonography in Kenyan public health institutions, Onyiego et al. (2021) used a descriptive cross-sectional approach. The research has found that the accuracy of diagnosis with ultrasound picture technology was low even if the technology was available due to poor training in picture interpretation. It was decided that investments to build up the ultrasound equipment with top modern technology and further education are crucial for improving diagnostic service quality. However, it did not explore the impact of access to good imaging and diagnostics on maternal health outcomes for rural women, specifically at Malindi Sub-County Hospital, despite its focus on healthcare providers' perspectives.

So when we go through literature we find that one of the advantages of high quality imaging, imaging interpretation is early detection of pregnancy problems, timely referral and improved maternal health care services. Previous studies have focused on the technical performance of portable ultrasound equipment, program implementation, or the competency of health workers, while neglecting to take into account the quality of the images or diagnostics achieved in rural areas of a country and how this influences women's maternal health outcomes. In addition, no research has specifically looked at this correlation among the female patients at Kilifi County's Malindi Sub-County Hospital. This research was needed due to the lack of information and empirical evidence stated above.

2.2.3 Cost of Portable Obstetric Ultrasound Services on Maternal Health Outcomes

One of the several variables that affect the use of vital maternal health care, such as portable obstetric ultrasound (pOU) services, is out-of-pocket health spending.

Logounov and Weber (2024) did an observation population-based study in Finland to research how publicly funded obstetric US services affect the usage of maternal health care services amongst pregnant women receiving normal prenatal care. When researchers made obstetric ultrasonography available without charge to all pregnant women, practically everyone used the recommended ultrasounds and issues along with problems for both the mother and the unborn could be detected earlier. The authors' conclusions are that ultrasonography, when included in publicly financed maternal health care packages, leads to better access equality and better outcomes of pregnancy. They have petitioned government to continue to financially support diagnostic research to ensure that all could receive care. However, low-resource health systems whose funding is mostly out-of-pocket may not be able to use the study's findings since it was conducted in a high-income health system with a complete universal health coverage system.

Similarly, Amoakoh-Coleman et al. (2022) adopted a cross-sectional analytical design to explore the association between healthcare financing and utilization of obstetric

ultrasonography services in public health care facilities in Ghana. Women from low socioeconomic status were compared to those from high socioeconomic status and women from low status groups were more likely to not undergo the recommended obstetric ultrasonography because of the high direct cost of the scan. The study may suggest that the inability to recognize pregnancy complications and adherence to prenatal care may be due in part to financial constraints. The authors recommended enhancing the coverage of the National Health Insurance Scheme's financial protection and more equitable distribution of diagnostic imaging services. The intention of the study was not to see if maternal health outcomes were correlated to the cost-effectiveness of the portable obstetric sonography intervention, but rather to explore factors that influence use of the service.

Ndikubwimana et al., (2026) employed a mixed-methods study design to evaluate its effect on improving access to maternity diagnostic services among Rwanda's rural population through a CBHI approach. The quantitative results revealed that eliminating user costs resulted in higher consultation rates for pregnant women in referral compliance and obstetric ultrasonography service and enhanced the early detection of high-risk pregnancies. Qualitative results suggested that women were more likely to adhere to prenatal care advice and complete desired diagnostic tests when provided financial protection. The researchers also recommended building of community-based health finance systems, which has been going hand in hand with development of portable ultrasonographic services at primary healthcare units. However, the research was not specific enough to consider the costs associated with the portable obstetric ultrasound services in relation to maternal health outcomes, but rather on healthcare finance strategies.

To explore nurse-midwives' practice of regular prenatal ultrasound in the remote area, researchers Hanson et al. (2025) chose a descriptive cross sectional research design with women who attended maternal health care (MHC) clinics that utilized FMNs.

The experiment was carried out to test the project feasibility and results. Many rural families are unable to afford the necessary prenatal health check-ups, with a single health checkup ultrasound costing between KSh 500 and KSh 2,500, the research noted. More negative maternal outcomes are likely when pregnancy-related problems are not diagnosed in a timely manner. So, the study called for more funding, public-private partnerships, and it to be used more extensively as a tool in publicly funded maternal healthcare programs as ways to make portable obstetric ultrasonography more accessible and affordable. The study accounted for the cost of services, however, it didn't examine the impact on the health outcomes for Malindi Sub-County Hospital in rural Kenya moms using the portable obstetric ultrasonography.

The current empirical literature was identified as potential significant influences on women's obstetric ultrasound examination in particular, but less so in low resource environments. Public financing, insurance coverage, and targeted subsidies to decrease financial constraints increase the usage of obstetric ultrasonography, improve the early diagnosis of obstetric problems, and boost referral systems, according to research from diverse situations. In contrast to the extensive literature on the health care finance effects on service use, there has been a lack of research on the impact of the cost of portable obstetric ultrasound services on maternal health outcomes.

Secondly, there is a lack of empirical data especially relating to the rural population who utilize Malindi Sub-County Hospital's maternal health services and who still face financial constraints despite interventions and who are at risk of not accessing the services. Thus, this study aimed at exploring theoretically and empirically the influence of the cost of obstetric portable ultrasound services on health outcomes of women who consumed obstetric portable ultrasound services at Malindi sub-county hospital in rural areas of Kilifi County, Kenya.

2.2.4 Usability of Portable Obstetric Ultrasound Services

Portability of obstetric ultrasonography is a crucial part of the services' ability to improve mothers' health outcomes. Items that are simple to use contribute to good maternal health outcomes including timely diagnosis of pregnancy problems, good clinical judgment, and timely and appropriate referral.

Brazilian midwives' understanding, perspective, and use of intrapartum ultrasonography were investigated by Packet et al. (2024) in a quasi-experimental research including medical students and midwives. The study revealed that competency-based training resulted in a significant increase in the confidence and competence of HOWs in the use of a portable ultrasound device. As a result, the accuracy of prenatal examinations at healthcare institutions (in rural areas) improved. Portable ultrasound equipment should be included into pre-service and ongoing professional development programs to assist service delivery, according to the authors. But the study did not ascertain whether or not competence of health care providers impacted maternal health outcomes for the pregnant women; nor if more user-friendly portable ultrasound services impacted on maternal health outcomes or not.

To further explore on the clinical acceptance and usefulness of portable ultrasound equipment in maternal care, De Souza (2025) conducted a mixed-methods research with obstetric doctors in Canada. The results revealed that portable ultrasonography was highly accepted by providers because it was very easy to use, reduced waiting time for patients for diagnosis, and expedited decisions for patients who were pregnant. The study's authors called for the need to provide users with better training and to make sonography more extensively available to other primary health care providers in the use of portable ultrasound. Findings may fail to be applicable to more rural and low income settings.

Abawollo et al., (2022) conducted an African cross-sectional implementation study to assess the impact of portable obstetric ultrasonography service innovation in reducing maternal and newborn morbidity and mortality in semi-urban health facility in Ethiopia. The findings indicated that portable ultrasonography had a positive impact on health care professionals' abilities to the following: 1) recognize high-risk pregnancies; 2) provide greater referrals for emergency obstetric care. Unfortunately, there was a lack of technical expertise, inconsistent maintenance and unreliable power that made the gadgets not very useful. In order to make the most of portable ultrasonography, the authors recommend investing in health infrastructure, providing technical support, and conducting continual training. However, the study was not on the impact of usability on the maternal health outcomes; it was on implementation problems.

Along similar lines, using a labor triage checklist upon ultrasound examination to refer pregnant women was explored by Santos et al. (2021) in three main health centres in Eastern Uganda. The staff with training using organized modules had more skills in using portable ultrasound machines, higher diagnostic findings of obstetric complications and higher referral timeliness. The research suggested that the neonatal care route should include the use of portable sonography and that the amount of competency based training should be increased. The relationship between portable ultrasound service use and maternal health outcomes was not directly measured but instead, the focus was on provider performance and service deployment.

Kamau (2025) in a descriptive cross sectional study among reproductive age women attending Thika level five Hospital in Kiambu County, Kenya, investigated the utilization of preconception health care services. Findings indicated improved prenatal determination and clinical decision making provided by portable ultrasound equipment for a certain type of individual training. To make portable ultrasound services more viable and sustainable, Kamau (2025) suggests the following among other measures: Continuous Professional Development,

Routine equipment maintenance, and the provision of more funds from the government. The role and impression of the petty POTUS, and institutional readiness to introduce the portable obstetric ultrasound to rural mothers' health outcomes, were under-researched.

The literature reviewed indicates that competency-based training efforts and appropriate technology and health systems would make portable obstetric ultrasound use more effective in improving maternal healthcare services. Thus far, the vast majority of research on portable obstetric ultrasonography has been directed at health professionals' competencies, technology use, and program implementation and not at the experience of rural women and their outcomes resulting from the portable ultrasound technologies in terms of maternal health.There is little empirical research that examines the impact of portable obstetric ultrasound on maternal health outcomes for rural women; most of this research has concentrated on women's health providers' competencies/capabilities, use of the technology and program implementation. In addition, the Malindi Sub-County Hospital does not have adequate contextual evidence, and factors such as provider expertise, resource availability, and health system capabilities can affect the utility of the portable obstetric ultrasonography. This incongruence of these findings and their context was used as a basis for the present investigation.

2.3 Research Gap

Table 1: Research Gap of Literature Reviewed

Author/Study Area	Focus of the Study	Key Findings	Identified Gap
Kim et al. (2021) – United States	Accessibility of portable obstetric ultrasound in rural maternal healthcare	Improved access enhanced early diagnosis of pregnancy complications, timely referral, and clinical decision-making.	The study was conducted in a well-resourced healthcare system, limiting applicability to rural public health facilities in Kenya.
Liu et al. (2021) – China	Quality of imaging and diagnostic performance of portable obstetric ultrasound	High-quality imaging improved early detection of placenta previa, fetal anomalies, and high-risk pregnancies.	The study focused on implementation and diagnostic performance without examining maternal health outcomes among rural women.
Maraci et al. (2022) – United Kingdom	Diagnostic accuracy of handheld obstetric ultrasound devices	Portable ultrasound achieved diagnostic accuracy comparable to conventional ultrasound for routine obstetric assessment.	The review synthesized evidence from high-income countries with advanced health systems, limiting relevance to low-resource settings.
Stewart et al. (2021) – Tanzania	Accessibility of portable obstetric ultrasound services in primary healthcare	Improved accessibility increased antenatal attendance and strengthened referral of high-risk pregnancies.	The study primarily evaluated programme implementation without establishing the relationship between accessibility and maternal health outcomes.
Amoakoh-Coleman et al. (2022) – Ghana	Cost of obstetric ultrasound services and service utilization	Financial barriers reduced utilization of ultrasound services, leading to delayed diagnosis of pregnancy complications.	The study examined healthcare utilization rather than the influence of affordability on maternal health outcomes.
Santos et al. (2021) – Uganda	Usability of portable obstetric ultrasound following healthcare worker training	Structured training improved provider competence, early diagnosis, and	The study emphasized provider performance and implementation without assessing

		referral of obstetric complications.	maternal health outcomes.
Onsongo et al. (2025) – Kenya	Accessibility of obstetric ultrasound services in Kilifi County	Long travel distances delayed antenatal attendance and diagnosis of pregnancy complications.	The study focused on geographical access and did not examine how accessibility influences maternal health outcomes among rural women.
Onyiego et al. (2021) – Kenya	Quality of obstetric ultrasound services in public health facilities	Limited provider competency reduced diagnostic accuracy despite the availability of ultrasound equipment.	The study focused on healthcare providers' perspectives rather than maternal health outcomes.
Hanson et al. (2025) – Kenya	Cost barriers to routine antenatal ultrasound services	High out-of-pocket costs delayed uptake of recommended ultrasound examinations among rural women.	The study concentrated on financial barriers to service utilization without examining maternal health outcomes.
Kamau (2025) – Kenya	Usability of portable ultrasound services in maternal healthcare	Provider training improved competency and efficiency in obstetric assessment.	The study focused on provider experiences and institutional preparedness rather than the influence of usability on maternal health outcomes.
Current Study – Malindi Sub-County Hospital, Kilifi County, Kenya	Influence of portable obstetric ultrasound services on maternal health outcomes among rural women	The study examines how accessibility, quality of imaging and diagnosis, cost, and usability of portable obstetric ultrasound services influence maternal health outcomes among rural women.	The study addresses the conceptual, contextual, and empirical gaps by examining the combined influence of the four dimensions of portable obstetric ultrasound services on maternal health outcomes within a rural public hospital setting in Kenya.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the research methodology that was used in the study. Research design, target population, size of and sampling technique used, data collecting instruments, techniques of data analysis, procedures for data collection, research instrument reliability and research instrument validity and ethical issues are specified.

3.2 Research Design

Gathering, analyzing and evaluating data are needed to achieve research goals, which involves having a plan (Lindhult & Axelsson, 2021). A convergent parallel design and mixed-methods approach were used to carry out the investigation. Creswell and Creswell (2023) showed that convergent parallel techniques involve collecting both qualitative and quantitative data side-by-side, analyzing each individually, and integrating them during the analysis or interpretation stages to obtain a holistic picture of the problem under study.

In a structured questionnaire, rural women attending the Malindi Sub-County Hospital for antenatal care were asked about the availability, quality of imaging and diagnostics, cost, use and usefulness and maternal health outcomes of portable obstetric ultrasound service. The qualitative component included key informant interviews (KII) with community health promoters and health care providers to delve into their experiences, thoughts, and challenges regarding the portable obstetric ultrasonography services.

Quantitative and qualitative data were triangulated in the study, underscoring the convergent parallel mixed-methods design, which enhanced the study's validity, credibility and completeness (Creswell & Creswell, 2023). The design fostered the inclusion of statistical evidence and the participants' experience to gain a fuller understanding of the research.

3.3 Study Area

This research was conducted in the Malindi Sub County Hospital, Kilifi County, Kenya. A significant proportion of the rural people of Malindi Sub-County do not have access to critical maternal health care services such as access to timely prenatal care, obstetric diagnostic services and obstetric referral services. Women's access to basic maternal health services is problematic as its poor diagnostic facilities, lack of trained healthcare professionals or geographic constraints (Kilifi County Government, 2024).

Malindi Sub-County Hospital is the main public hospitals in the Sub-County which provides comprehensive maternal health services such as prenatal care, delivery room services, emergencies obstetric services, postnatal care, and diagnostic imaging. Several health institutions, including a number of lower level facilities were contacted by the hospital for their need for obstetric ultrasonography services and the hospital were unable to provide it. The mobile obstetric ultrasound is now available at the hospital and can help rural women access diagnostic imaging services more easily, potentially early diagnosis of pregnancy-related issues.

A purposive sample technique was used in the selection of the research site due to its mostly rural population, high demand for obstetric services and poor diagnostic imaging scheme at outlying health centres. These characteristics led to the use of portable obstetric ultrasound for research where factors that impact maternal health in association with imaging and diagnostic quality, affordability, and ease of use could be investigated. The study's findings might help implement and scale up portable obstetric ultrasonography services in other resource-limited and rural contexts in Kenya.

3.4 Target Population

When a researcher intends to reach conclusions from the research, the entire realm of people having the required qualities is known as the target population (Creswell and Creswell 2023). This research focused on the Malindi Sub-County Hospital as the primary provider of services such as prenatal care services, the dominant clientele group being pregnant women, who attended the services and thus became the target for the use of portable obstetric ultrasonography services. Healthcare professionals included nurses, midwives, sonographers and also Community Health Promoters, who also have an important role in promoting and delivering maternal health services.

At Malindi Sub-County Hospital, a total of 5,000 pregnant women received ANC services in 2024 based on the Annual Maternal Health Register in the hospital. Fifteen community health promoters assisted in referring, educating, and/or following up with mothers who needed healthcare while 50 medical professionals worked directly with the mothers to provide healthcare. Overall target population of 5,065 participants was identified as shown in table 2.

Although the study will be completed in 2026, the most recent full year of population data when the study's population and list of eligible individuals (sample frame) was determined were the 2024 Annual Maternal Health data. The most recent full yearly records were used to ensure that maternal health data consistently recorded was used in the population estimate for sampling and population verification. This provided a good basis for the population of this study.

Table 2: Target Population

Category	Target Population	Percentage (%)
Pregnant women attending ANC	5,000	98.72
Healthcare providers	50	0.99
Community Health Promoters	15	0.29
Total	**5,065**	**100.00**

Source: Malindi Sub-County Hospital Annual Maternal Health Records (2024).

3.5 Sample Size and Sampling Techniques

Here we detail the processes that went into deciding on a sample size and the methods that were utilized to choose research participants. There is an adequate sample size and acceptable sampling procedure which enhances the reliability and validity of the results of the study.

3.5.1 Sample Size

Researchers choose a certain number of people from a larger population in order to create a representative sample for a research (Ahmed, 2024). In this study, the sample size was determined using Yamane's formula (1967) which is applicable to small population. This can be written as the equation:

$$n = \frac{N}{1 + \mathrm{N(e2)}}$$

Where:

n = required sample size

N = total population (5,000 pregnant women)

E = margin of error (5% or 0.05)

$$n = \frac{5000}{1 + 5000(0.05)(0.05)}$$

n= 370.37

Therefore, the group of 371 participants was deemed to be sufficient sample size. This meant that a quantitative survey was administered to 371 pregnant women. In addition, 15 Community Health Promoters (CHPs) and 10 healthcare clinicians were strategically selected as key informants. This resulted in a total sample of 396 for the study.

3.5.2 Sampling Techniques

Different sampling procedures were used for quantitative and qualitative research. The pregnant women who visited Malindi Sub-County hospital prenatal clinic were sampled using a systematic random sampling technique and ended with 371 pregnant women. The registry of the ANC was used as the sample frame to identify eligible subjects:

$$k = N/n$$

$$k = 5{,}000/371 = 13.48 \approx 13$$

Therefore, using the ANC registry, one lady was selected each week until she gave birth. To ensure that we achieved the desired sample size of 371 participants, we first randomly selected a starting point between 1 and 13 and then randomly selected the eligible lady every 13th. This was methodical with participants selected in an organized manner, so there was less chance of selection bias.

The qualitative portion included purposive sampling of ten doctors and hospitals providing and using a portable obstetric ultrasonography. The same selection principles were used for fifteen community health promoters in Malindi Sub-County, who were believed to be engaged in maternal health education, referral and community outreach. Candidates were chosen based on their expertise in the field, relevant work experience, and access to comprehensive contextual information about maternal health outcomes as it pertains to portable obstetric ultrasound services.

3.6 Data Collection Instruments

In order to achieve the research goals, data collecting devices are used to systematically get information from study participants (Mwanje, 2021). In order to get quantitative data, 371 pregnant women who visited prenatal care services were given structured questionnaires. Interview was used to collect qualitative data by interviewing 10 healthcare personnel in Malindi Sub-County Hospital using interview guidelines.

3.6.1 Questionnaire

According to Toyota (2021), questionnaires are standardized data collection tools that are designed to achieve the research objectives, and seeks to gather comparable information from the respondents. Questionnaires give researchers the ability to obtain data from a large number of people in a short period of time and minimize interviewer bias and enhance the reliability of the responses. (Mwanje, 2021). In the present study, the participating pregnant women were asked to complete a fixed standard questionnaire, which comprised the closed answering questions by using a five-point scale. To obtain the information required to achieve the aims of the study, a questionnaire was developed to collect information on maternal health outcomes, ease of use, costs, and quality of imaging and diagnosis when using portable obstetric ultrasonography services.

3.6.2 Interview Guide

Using an interview guide as a data gathering approach, it is a qualitative method that enables to have an in-depth interview with selected participants to elicit more detailed information about the phenomena being studied (Thomas, 2022). It allows you to explore in any way you like, but still ensures that you cover all bases in terms of your research. In this study, a sample of 15 community health promoters and 10 healthcare professionals in practice (PhN, nurse, midwife, obstetrician and sonographer) were intentionally selected to serve as key informants. Interviews were carried out and qualitative data was gathered by using an interview guide. Interview guide to identify participants' perspectives, thoughts and feelings on the introduction, use and impact of portable obstetric ultrasound services on mother health outcomes was used at Malindi Sub-County Hospital.

3.7 Pilot Testing, Validity, and Reliability of Research Instruments

3.7.1 Pilot Testing

A pilot research is carried out prior to the major research to check the clarity, reliability and validity of the instruments used for data collection in the study (Munivrana et al., 2022). The Kilifi County Referral Hospital was used for a pilot project due to its resemblance with Malindi Sub-County Hospital. The final research did not include any analysis of the data collected from the pilot trial. The sample size used for pre-testing the created research instruments was 37 respondents (10%) which is considered as a minimum sample as per the suggestion of Mugenda & Mugenda (2019). The main data collection was preceded by this pilot research to ensure the questionnaire and the interview guide were clear, relevant, well-sequenced and comprehensive. It also attempted to find out the ambiguities, if any. The instruments were fine-tuned in terms of their understandability and applicability for the full study, in response to the comments given during the research of pilots.

3.7.2 Validity of the Research Instruments

Sürücü and Maslakçı (2020) state that if a research instrument measures the variables that are intended to be measured, it can be assumed that the instrument is valid. The questionnaire and interview guide were content validated by the University faculty and experts in maternal health and research methods. Due to their feedback and suggestions, we were certain that the instruments captured all the research factors. In addition, the questions were face-validated in the pilot study to ensure the questions would be clear, relevant, and appropriate for the target audience. The instruments were fine-tuned based on the input received prior to the data collection.

3.7.3 Reliability of the Research Instruments

Ahmed (2024), for instance, defines a research instrument to be reliable when it gives a consistent and dependable data under the same conditions. We examined the internal consistency of the questionnaire using Cronbach's Alpha, a reliable statistic for measuring the dependability of such items as measured on a Likert Scale. According to Jarupunphol et al. (2024), an appropriate level of dependability is obtained when the Cronbach's Alpha coefficient is ≥ 0.70. If the alpha coefficient of one of the constructs is lower than the recommended value, it will be modified before being used in the main research. You can see the results of the reliability tests in Table 3.

Table 3: Reliability Test Results

Variable	Cronbach's Alpha	Numbers of Items	Comment
Portable obstetric ultrasound services accessibility	0.85	8	Reliable
Quality imaging and diagnostics on the early detection	0.82	8	Reliable
Cost of portable obstetric ultrasound services	0.83	8	Reliable
Usability of the portable obstetric ultrasound services	0.87	8	Reliable
Maternal Health Outcomes	0.84	8	

There was medium to excellent internal consistency across all constructs, according to the results. There was good reliability between the nine items on the survey with Cronbach's Alpha of 0.85 for maternal health outcomes, 0.82 for accessibility of portable obstetric ultrasound services, 0.83 for cost, 0.87 for usability, and 0.84 for imaging and diagnostics services for early detection. The results show that the item questions in the questionnaire were appropriate to measure the variables, organized and coherent. Based on the results obtained, it can be said that this instrument was reliable and valid to be used in primary research.

3.8 Data Collection Procedure

Data collection started once the required Ateising wa-nene, (Ethical approval) from the Directorate of study at CUEA and NACOSTI (National Commission for Science, Technology and Innovation) was received. We were then given the nod to undertake research by people at Malindi Sub-County Hospital and Kilifi County Department of Health.

Following this the researcher and two research assistants visited the study site to inform participants about the aim of the study. Pregnant women who visited a prenatal care clinic were selected by systematic random sample method from the inclusion criteria pregnant women. The health care personnel for this study were hand-picked because of their direct participation in the provision of health care services to mothers, including the services of portable obstetric ultrasonograph. Prior to the data collection all participants were provided with the explanation of the studies aim and given written consent to participate. The participants also had the opportunity to withdraw from the study at any time without repercussions and their comments were guaranteed to be kept confidential and anonymous.

A simple questionnaire was designed, and all the selected pregnant women were asked to take the questionnaire so as to obtain quantitative data. Results for mothers, as well as information on the accessibility, diagnostic accuracy, cost, and ease of use of portable obstetric ultrasound services, were gathered via the questionnaire. The respondents were allowed to conduct the surveys on their own, but with clarifications given by the researcher and research assistants when they needed it.

Data were gathered from key informants as qualitative information through in-depth interviews with an interview guide. Each interview was recorded with the participants' consent, and supplemented by field notes which provided the participants' background information.

Data collection was completed after which questions were checked for correctness, consistency and completeness in a double-check for coding purposes. Thematic analysis was done with

qualitative (word-to-word) transcribed interview data and quantitative data was entered in IBM SPSS Statistics Version 27. To ensure high level of data quality, adherence to study protocol and ethical issues, the researcher monitored the research assistants during the process of data collection.

3.9 Data Analysis Techniques

Data analysis involves organizing, coding, analyzing, and interpreting the collected data in a systematic manner, with the aim of reaching the desired objectives of the study (Bingham, 2023). Convergent parallel mixed-methods approach was followed to analyze the quantitative and qualitative data separately and then integrate them to form conclusions.

The questionnaires were completed and following completion, quantitative data was cleaned, coded and imported in SPSS Version 27 by IBM for analysis. Descriptive statistics such as frequencies, percentages, means and standard deviations were used to describe the demographic characteristics of the respondents and the variables of the study. Using inferential statistics we then determined the degree of the correlation between the realization of maternal health outcome and portable obstetric sonography service. In this study, Pearson Product-Moment Correlation Analysis was performed to know the relationships of the study variables in terms of association and correlation. The individual and combined influences of portable obstetric ultrasound services' accessibility, imaging and diagnosis quality, cost, and usability on maternal health outcomes were determined through multiple linear regression analysis. The following is the expression for the regression model:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\varepsilon$$

Where:

Y = Maternal health outcomes;

X_1 = Accessibility of portable obstetric ultrasound services;

X_2 = Quality of imaging and diagnosis;

X_3 = Cost of portable obstetric ultrasound services;

X_4 = Usability of portable obstetric ultrasound services;

β_0 = Constant (intercept);

$\beta_1 - \beta_4$ = Regression coefficients; and

ε= Error term.

The model was used to establish the predictive relevance and importance of the independent variables with respect to the maternal health outcomes at a 5% level of significance ($p < 0.05$). Using theme analysis, which was suggested by Braun and Clarke (2022), the verbatim transcriptions of the interview guides were used to examine the qualitative data. The transcripts were read several times to familiarise themselves with the information, and they were then categorised by systematic coding. Next, the categories were extracted from which the themes emerged. The identification process resulted in themes depicting the participants' clinical experiences, attitudes and opinions regarding the use and implementation of POU services for the improvement of maternal health outcomes.

The triangulation was done in the interpretation step in order to unite quantitative and qualitative results. Elucidating, supporting, and contextualizing the findings in the qualitative data resulted in a more comprehensive grasp of the impact that the implementation of portable obstetric ultrasound services had on the well-being of women living in rural areas, alongside the quantitative findings. This was done by utilising Malindi Sub-County Hospital in Kilifi County.

3.10 Ethical Considerations

It is important that a research should have research ethics to safeguard the rights of the research participants, their dignity, privacy, and welfare as well as to ensure that the research is credible and trustworthy (Resnik, 2020). Data was collected after approval of the Directorate of Research of CUEA was obtained. After this, the Kilifi County Department of Health (KCDOH)

and the management of Malindi Sub-County Hospital (MSSC) both consented to conduct research in the hospital and a research permit was eventually obtained from NACOSTI.

All participants consented to participate in the research on a voluntary basis. Prior to any data collection, all study participants were provided with information about the study, its objectives, procedures, the anticipated time required for participation and their rights. We obtained written informed consent of the participants before interviewing/carrying out surveys. Additionally, participants were made aware that they might discontinue participating or resign from the research at any point without facing any consequences or losing any advantages.

Always, the researcher respected participants' identity and confidentiality. No attempt was made to collect any personal data including names on the instruments used and all data collected was utilized solely for academic purposes. Completed surveys, interview recordings and transcripts were stored encrypted and could only be accessed by the researcher. To anonymize the results, the results were presented in an aggregated manner.

During the research a clear ethical approach regarding the conduct of scientific research was followed. This involved following principles of respect for participants, beneficence, confidentiality, informed consent and voluntary participation.

Table 4: Operationalization of Variables

Variable	Indicators	Research Instruments	Measurement Scale	Type of Analysis	Tools of Analysis
Accessibility of portable obstetric ultrasound services	Availability of portable ultrasound services within reasonable distance Affordability of obstetric ultrasound services for pregnant women Frequency of use of obstetric ultrasound during antenatal visits. Timeliness in accessing portable ultrasound services when needed	Questionnaires, Interviews,	Interval	Descriptive Statistics Inferential Statistics	Frequency, Percentages, Mean, standard deviation, Correlation Analysis of variance
Quality of Imaging and Diagnostics of portable obstetric ultrasound services	Timeliness of identifying high-risk pregnancies using tool. Clarity and resolution of ultrasound images Consistency and confidence in imaging interpretation Accuracy of diagnosis of high-risk pregnancies using tool.	Questionnaires, Interviews	Interval	Descriptive Statistics Inferential Statistics	Frequency, Percentages, Mean, standard deviation, Correlation Analysis of variance

Cost of portable obstetric ultrasound services	Average fee charged for a single ultrasound session Perceived affordability of ultrasound services by expectant mothers Out-of-pocket expenditure on ultrasound services Financial constraints among expectant mothers	Questionnaires, Interviews	Interval	Descriptive Statistics Inferential Statistics	Frequency, Percentages, Mean, standard deviation, Correlation Analysis of Variance
Usability strategies of portable obstetric ultrasound services	Ease of use of portable ultrasound equipment by healthcare providers Clarity and accuracy of ultrasound images produced Training and competence of healthcare providers in using portable ultrasound devices Patient understanding of the ultrasound procedure and results	Questionnaires, Interviews	Interval	Descriptive Statistics Inferential Statistics	Frequency, Percentages, Mean, standard deviation, Correlation Analysis of Variance
Maternal Health Outcomes	Frequency of ANC visits. Early detection of high-risk pregnancies.	ANC records, Questionnaires, Key Informant Interviews	Interval	Descriptive Statistics	Frequency, Percentages, Mean, standard deviation, Correlation

	Number of pregnancy complications. Maternal and neonatal health indicators			Inferential Statistics	Analysis of Variance

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This section presents the details of findings of research regarding the connection between maternal health outcomes and provision of portable obstetric ultrasound services for women in rural areas in Kilifi County at the Malindi Sub-County Hospital. The aims of this chapter are to discuss in detail the data obtained, to interpret what the results are in relation to the objectives of the study and to discuss what the results are in relation to the previous research. This resulted in focusing the presentation of the results around the specific objectives of the study: to make portable obstetric ultrasound services more accessible; to improve imaging and diagnostics for early detection; and to make these services more usable and cost effective. In this chapter, relevant quantitative and qualitative findings, together with discussion and interpretation were cast into the light of respective targets to present a comprehensive picture of association between the maternal health outcomes among rural women and the portable obstetric ultrasound services.

4.1 Respondents' Return Rate

Here we can see the proportion of people that were really involved with the research. A systematic random selection method and purposive sampling method were combined in order to ensure the representation of each category in the sample. The questionnaires were sent to 371 pregnant women which resulted in about 98.4 percent response rate (365 responders). Further, there was 100% response among the 25 key informants interviewed in the study specifically selected for qualitative interviews out of 390 respondents. Look at the percentage of responses in Table 5.

Table 5: Response Rate

Category of Participants	Sample Size	Response Response Rate (%)	
Questionnaire Respondents			
Pregnant women participants			
Subtotal	371	365	98.4
Key informants (qualitative)	25	25	100
Total	**396**	**390**	**98.5**

Source: Field Data (2026)

The sample number of people who participated in this research was large (Table 5). The 365 questionnaires, sent out to pregnant women, were actually returned, representing 98.4% of all questionnaires sent. We used see how many of these informants that were out there that were important and made an effort to contact all of them and got a complete response rate from our interviews. There was a 98.5% response rate overall.

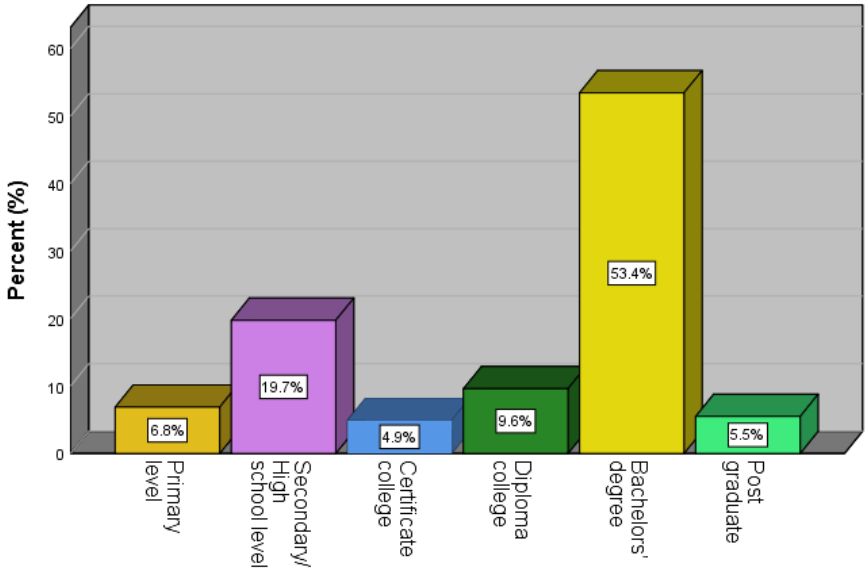
The scores for involvement are high, meaning that patients and Health Care Stakeholders are involved. The few respondents who did not complete the questionnaire and the full involvement of key informants help to improve the completeness and trustworthiness of the data. Saunders, Lewis, and Thornhill (2023) consider a 98.5% return rate to be strong in the realm of social research, further supporting the findings of the study.

4.2 Demographic Statistics of Participants

In this part, we discuss the demographic features of the 365 persons who filled out the survey questionnaire. These qualities are essential when compiling the research population, and in identifying trends. Demographic data was presented in the form of tables and figures followed by a discussion of the key trends and implications for access to portable obstetric ultrasonography services for rural women and their maternal health outcomes.

4.2.1 Highest Level of Education

Here we provide the results on the respondents' greatest degree of schooling. Capturing what level of education the research participants have is important in order to be able to access, interpret and use the health related information. This is particularly the case with regard to maternal health outcomes and with regard to portable obstetric ultrasonography services. The results were demonstrated in figure 2.



Source: Field Data (2026)

Figure 2: Education Level of Respondents

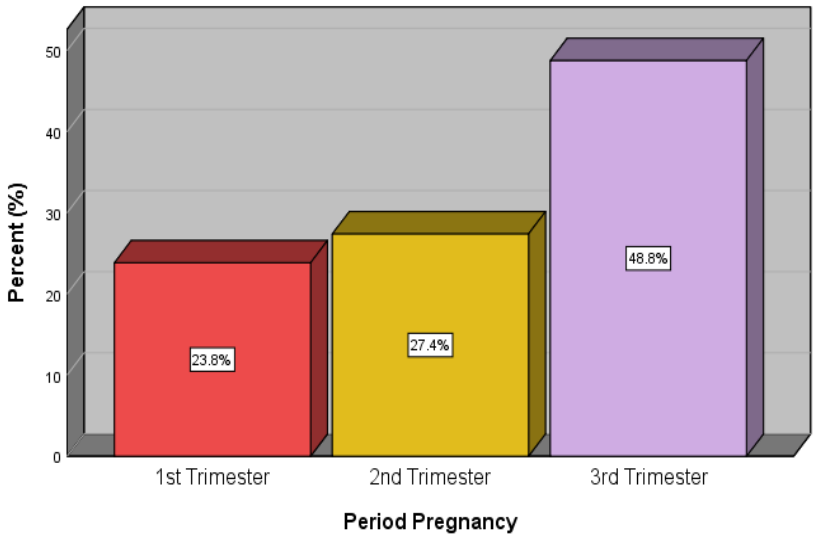
Almost half of the population (195, 53.4%), as shown in Figure 2, had a bachelor's degree. 72 respondents (19.7%) had a high school diploma, 35 (9.6%) respondents had a secondary diploma and one (0.3%) respondent had no formal education. Eighteen people (4.9%) completed certificate level education, 25 people (6.8%) completed elementary education, and 25 people (5.5%) completed graduate education. The research area's pregnant women seem to have a high level of education, since the majority of respondents had a tertiary degree.

That is fundamental to comprehending the data, as it is one of the comparatively high levels of education. Menzli et al. (2022) stated that students with higher education have a greater tendency to accept and make best use of the new technology owing to the exposure they are

getting from the innovation, analysis skill or even a full load of knowledge. Therefore, it is possible that the high knowledge and good usage of portable obstetric ultrasound services in this research are due to the participants' high levels of education. Fewer respondents however, completed elementary school or had a certificate, which may indicate the gaps in health literacy impacting the population's understanding and utilization of ultrasound services. People in the community with lesser levels of education would not be able to use these findings as broadly because of this.

4.2.2 Period of Being in Pregnancy

This section will show the findings of this study concerning the length of pregnancy of the pregnant women. Factors such as respondents' experience of maternal health care, the number of prenatal check-ups attended, and use of portable obstetric ultrasound services to monitor baby development and maternal health may be related to the trimester of pregnancy, so the information becomes important. The results were displayed in figure 3.



Source: Field Data (2026)

Figure 3: Participants Period of Pregnancy

Results found that 87 (23.8%) respondents were in the first trimester, 100 (36.4%) in the second trimester and 178 (48.8% of the total) in the third trimester. Almost half of the females surveyed were in the third trimester of pregnancy.

This distribution shows more access to maternal health care will be available in the third trimester when monitoring is most critical. According to World Health Organization, 2023, ANC consumption is highest during the second and third trimester due to increased risk monitoring/preparation of labor. Conversely, there may be a smaller proportion of women in their first trimester which is associated with booking ante-natal care later and this is an issue for those in the far regions. This means that a range of issues while pregnant can remain undiagnosed.

4.3 Results and Discussion

This section presents the obtained results, interpretation, and discussion of the findings of the study in the light of the goals of the study. It exists in quantitative form, as surveys were conducted with rural women, while qualitative form, performed key informant interviews, combine the two to assist in understanding the correlation between POUS and MHOs.

4.3.1 Portable Obstetric Ultrasound Services Accessibility and Maternal Health Outcomes

Maria J. Kothari and colleagues assessed the maternal outcome for women at Malindi Sub-County Hospital, Kilifi County, Kenya, in the light of the ease of access for provision of portable obstetric ultrasonography (OBUS). There were no other goals defined in the study that matched this one. The study highlights the linkage between the accessibility of ultrasound services and the level of maternal access to health care and the significance of early detection of foetal abnormality to the mother and child. Results obtained from the questionnaires were presented to the respondents (N=365) in table 6).

Table 6: Response on Portable Obstetric Ultrasound Services Accessibility

n=365

Statements	SD % F	D % F	N % F	A % F	SA % F	Mean	Std Dvt
Portable obstetric ultrasound services are available within a short distance from my home.	18 (4.9)	33 (9.0)	41 (11.2)	168 (46.0)	105 (28.8)	3.85	0.96
I know where to access portable ultrasound services during my pregnancy	15 (4.1)	28 (7.7)	36 (9.9)	172 (47.1)	114 (31.2)	3.93	0.91
The cost of accessing portable obstetric ultrasound services is affordable for me.	41 (11.2)	56 (15.3)	51 (14.0)	137 (37.5)	80 (21.9)	3.44	1.21
There are financial challenges involved when seeking portable ultrasound services.	22 (6.0)	36 (9.9)	39 (10.7)	147 (40.3)	121 (33.2)	3.85	1.05
I had at least one portable ultrasound scan during my antenatal care visits.	12 (3.3)	25 (6.8)	30 (8.2)	178 (48.8)	120 (32.9)	4.00	0.89
Healthcare providers regularly recommended the use of portable ultrasound during my pregnancy.	14 (3.8)	30 (8.2)	41 (11.2)	162 (44.4)	118 (32.3)	3.93	0.95
I was able to access portable ultrasound services without long waiting times.	30 (8.2)	43 (11.8)	49 (13.4)	147 (40.3)	96 (26.3)	3.66	1.13
Whenever a portable ultrasound was needed, it was readily available at the clinic	20 (5.5)	36 (9.9)	46 (12.6)	157 (43.0)	106 (29.0)	3.77	1.02
Composite Mean and Standard Deviation						**3.80**	**1.02**

Source: Field Data (2026)

The results showed that the respondents had a general consensus that the portable obstetric ultrasonography services were available in Malindi Sub-County Hospital with a composite mean of M = 3.80 and SD = 1.02 (Table 6). Based on the results, it could be said that this Portable Obstetric Ultrasonography service can be enhanced to improve maternal health of the rural women. This in turn encourages high uptake of prenatal care services which helps to detect complications of pregnancy in the early stages and promotes good maternal health.

Portable obstetric ultrasonography services were available within a short distance from the respondents' homes 168 (46.0%) strongly agreed, 105 (28.8%) agreed, 41 (11.2%) were

indifferent, 33 (9.0%) disagreed and 18 (4.9%) severely disagreed. Participants generally perceived the services to be geographically accessible with its mean score (M = 3.85, SD = 0.96). This study found that since the decentralization of portable ultrasound services, more pregnant women were able to receive the services without having to travel long distances to receive diagnostic services. The findings are consistent with the observations of Kim et al. (2021) that the availability of portable ultrasonography services in healthcare institutions in rural areas resulted in improvements in maternal healthcare delivery and early detection of pregnancy problems. According to the Health Belief Model (Rosenstock, 1974), women will be more likely to access maternal health care that is preventative in nature when they feel there are fewer difficulties to accessing and using health care.

This theory was supported by the qualitative findings. K1 clarified that *"since portable ultrasound machines were introduced, many women no longer have to travel to Kilifi County Referral Hospital for routine scans because the services are now available within the sub-county."* Similarly, K3**,** observed that *"women who previously delayed antenatal visits because of long travel distances are now attending clinics earlier since ultrasound services are closer to them."* Based on these responses, there has been a recent increase in the use of prenatal diagnostic services as a result of improvements in geographical access.

With respect to the participants being informed about where to obtain access to a portable ultrasound when pregnant, 172 (47.1%) agreed, 114 (31.2%) strongly agreed, 36 (9.9%) were indifferent, 28 (7.7%) were in disagreement and 15 (4.1%) were in strong disagreement. The respondents achieved a mean score 3.93 (SD = 0.91) indicating their high level of understanding related to the advantages of ultrasonography. This finding adds weight to the argument that prenatal counseling and health education has boosted females' acquaintance with prenatal diagnostic options. The findings are consistent with those of Yadav et al. (2020) who found an increased uptake of prenatal diagnostic services in rural India among women who

were made more aware of the use of ultrasound. As a signal to take action, health belief model states that women should seek out maternity health care as they become aware of the need.

This was reflected in the qualitative findings. K2, it was said, *"during every antenatal clinic, mothers are informed about the importance of ultrasound scans and where they can receive the service."* Likewise, K4, noted that *"community health promoters regularly educate pregnant women during household visits and community meetings on where and when to obtain ultrasound services."* The results indicate another way that there has been some improvement in health education knowledge and utilization of available health education services due to continuous health education.

137% agreed, 82% strongly agreed, 51% were unsure, 56% opposed, and 41% strongly opposed that portable obstetric ultrasonography services were inexpensive. The affordability indication had the lowest rating, a mean score of 3.44 (SD 1.21) that is one of moderate agreement. This finding suggests that despite the improvements in physical access to the services, there are some rural women who still experience financial access problems. This data supports the research findings of Onsongo et al. (2025) which indicated that one of the major challenges for obstetric ultrasonography services in Kilifi County was the high price. It suggests that according to the Health Belief Model, individuals are less likely to use health care when they are aware of the benefits if there are impediments to its use, such as if there are financial costs involved.

This theory was supported by the findings from the qualitative results. As the sonographer K5 talked about the fact that. *"although the ultrasound charges are lower than in private hospitals, some mothers still struggle to raise the required amount, especially those from low-income households."* Similarly, K3 observed that *"some pregnant women postpone their scans because they first have to find money for transport and hospital expenses."* The results show that there

are still monetary obstacles that prevent people from having equal access to portable ultrasound services.

When asked if work can obtain portable ultrasound services may be expensive, 147 (40.3%) responded agree, 121 (33.2%) respond strongly agree, 39 (10.7%) were unsure, 36 (9.9%) responded disagree and 22 (6.0%) responded very disagree. Participants largely recognized the financial challenges involved with receiving ultrasonography services, as shown by the mean score of 3.85 (SD = 1.05). Many of them were health care resources also, this study highlights that income of the family is still one of the critical factors of maternal health care consumption. This conclusion is corroborated by the qualitative data. As K2 pointed out, *"most women are willing to undergo ultrasound examinations, but financial constraints sometimes delay the recommended scans."* Likewise, K1 explained that *"economic hardship remains one of the reasons why some expectant mothers miss scheduled ultrasound appointments."*

Of those who responded, 178 (48.8%) agreed, 120 (32.9%) strongly agreed, 30 (8.2%) were neutral, 25 (6.8%) disagreed and 12 (3.3%) strongly disagreed with the statement that respondents received at least one portable ultrasound scan during their prenatal care visits. The overall score for the top ranked accessibility indicator is 4.00 (SD 0.89), suggesting high level of agreement. The finding adds to the mounting evidence that mobile ultrasound comes with the price of prenatal care these days. This validates the findings of Stewart et al. (2021) who showed that when ultrasound is made more portable to pregnant women living in rural Tanzania, there is more and more recent utilization of prenatal care, and more identification of high-risk pregnancies. This is also the case in the Health Belief Model when "coping benefits" are readily available and the benefits are seen clearly.

These results were confirmed by the qualitative findings. According to K5, *"almost every pregnant woman attending the recommended antenatal clinics receives at least one ultrasound examination unless there are exceptional circumstances."* Similarly, K2 noted that *"ultrasound*

has become part of routine antenatal assessment, especially for women suspected of having pregnancy complications."

As for the statement that health care workers conventionally asked pregnant women to use ultrasound machine for mobile or home use, 144 (44.4%) agreed, 118 (32.3%) very agreed, 41 (11.2%) were not sure, 30 (8.2%) disagreed, and 14 (3.8%) very disagreed. The mean (SD) score of 3.93 (0.95) indicates that portable ultrasound services repeated to the respondent's location were a common recommendation of healthcare professionals. The results of this study point to the importance of healthcare professionals in encouraging the use of maternal diagnostic tests. The recommendations of healthcare professionals play a major part in encouraging women to adopt health-protecting behaviours (HBM).

This was supported by qualitative results as well. According to K1, *"we encourage every pregnant woman to regularly undergo ultrasound scans during ANC visits because it helps us detect complications early and plan appropriate care."* Likewise, K4 observed that *"community health promoters consistently advise expectant mothers to attend all the scheduled antenatal visits where ultrasound services are available."*

Regarding the statement that "portable ultrasound services would be readily available and easily obtained by respondents", 147 (40.3%) agreed, 96 (26.3%) strongly agreed, 49 (13.4%) were ambivalent, 43 (11.8%) disagreed and 30 (8.2%) strongly disagreed. Although waiting time was still a considerable worry, the overall agreement was shown by the mean score of 3.66 (SD = 1.13). This report suggests that in certain cases the demand for ultrasound services is greater than the number of staff and apparatus is available, which affects the efficiency of the service.

This was ascertained with the results of the qualitative analysis. K5 said that *"on busy clinic days, patients sometimes wait longer because only a few trained staff operate the portable ultrasound machines."* Similarly, K2 explained that *"staff shortages occasionally increase waiting time, although emergency cases are attended to first."*

Regarding access to portable ultrasound services in the clinic, 157 were in agreement, 106 in strong agreement, 46 were indifferent, 36 were in disagreement and 20 (or 5.5% of the participants) were severe disagreeers. Most of the respondents felt that the services could easily be reached at any time with a mean score of 3.77 (SD = 1.02). At Malindi Sub-County Hospital, this data suggests that there has been a lot of success in integrating portable ultrasonography into normal maternity healthcare services.

The qualitative results corroborated this view. According to K1, *"the hospital has significantly improved the availability of portable ultrasound services compared to previous years, although occasional equipment maintenance may interrupt services."* Likewise, K3 stated that *"most women who attend the antenatal clinic are able to receive ultrasound services on the same day unless there are technical challenges."*

The quantitative and qualitative results indicate that the overall geographical accessibility, awareness, provider recommendation, and routine use in the frame of regular ante-natal care have significantly led to an improved maternal health-care delivery approach of the portable obstetric ultrasound services in Malindi Sub-County. Unfortunately, however, wait times and inadequate funding remain challenges to equitable access.

4.3.2 Quality Imaging and Diagnostics on the Early Detection and Maternal Health Outcomes

This section presents the results of the study's second specific objective, which was to examine the effect of the performance of early detection and diagnostic accuracy with maternal health outcomes of pregnant women in Malindi Sub County Hospital, Kilifi' County. It highlights the

potential future of emerging portable obstetric ultrasound imaging technologies and its possible enhancing effect on maternal and fetal health through greater ability to identify problems early, with greater accuracy and clarity. The results obtained from the questionnaires responses of 365 respondents are presented in table 7.

Table 7: Response on Quality Imaging and Diagnostics on the Early Detection

n=365

Statements	SD % F	D % F	N % F	A % F	SA % F	Mean	Std Dvt
The ultrasound images were clear enough for the healthcare provider to make a diagnosis.	10 (2.7)	22 (6.0)	36 (9.9)	177 (48.5)	120 (32.9)	4.03	0.88
The quality of imaging met my expectations for identifying pregnancy complications	12 (3.3)	25 (6.8)	41 (11.2)	171 (46.8)	116 (31.8)	3.97	0.92
The portable ultrasound accurately detected issues related to my pregnancy.	15 (4.1)	28 (7.7)	39 (10.7)	172 (47.1)	111 (30.4)	3.92	0.97
I trust the diagnostic information provided after my ultrasound examination	11 (3.0)	20 (5.5)	43 (11.8)	174 (47.7)	117 (32.1)	4.00	0.89
Potential pregnancy complications were detected early during my prenatal visits.	18 (4.9)	30 (8.2)	46 (12.6)	162 (44.4)	109 (29.9)	3.85	1.03
During antenatal, health-care providers used the ultrasound results promptly to plan my care	14 (3.8)	26 (7.1)	41 (11.2)	167 (45.8)	117 (32.1)	3.95	0.94
The healthcare provider appears confident while interpreting ultrasound results.	9 (2.5)	18 (4.9)	37 (10.1)	180 (49.3)	121 (33.2)	4.06	0.85
The diagnosis and explanations are consistent with other medical assessments I receive.	13 (3.6)	24 (6.6)	42 (11.5)	172 (47.1)	114 (31.2)	3.96	0.91
Composite Mean and Standard Deviation						**3.97**	**0.92**

Source: Field Data (2026)

The results indicated that the general level of satisfaction about the imaging and diagnostic services achieved by the portable obstetric ultrasound was satisfactory (M = 3.97, SD = 0.92) as seen in Table 7. The minimal difference in the standard deviations in the various indicators implies that respondents' views are consistently shared. High-quality imaging and precise

diagnosis, as evidenced by these results, may lead to faster clinical diagnosis and intervention and improve mother health outcomes.

Of the responses 120 (32.9%) strongly agreed, 177 (48.5%) agreed, 36 (9.9%) were neutral, 22 (6.0%) disagreed, and 10 (2.7%) very disagreed that the healthcare provider could diagnose the situation based on the ultrasound images. The mean value and standard deviation of the statement was 4.03 and 0.88 respectively, indicating that most of the respondents were agreeable to the sharpness of ultrasound pictures. This validate the expectation of improved accurate diagnosis by using a good imaging and thus better clinical decision being made throughout prenatal treatment. This validates the findings of Liu C et al. (2021), who reported that smoothly captured ultrasound images might be superior in the diagnosis of any abnormal presentations of the fetus, placenta previa or other fetal abnormalities and may result in better delivery-related outcomes for those women that received prenatal treatment. The finding facilitates acceptance and integration of the innovation into the routine of everyday healthcare, as predicted from the Diffusion of Innovation Theory (Rogers, 2003) of the fact that innovations that have tangible benefits and high performance are easier to accept. This was confirmed by the quantitative and qualitative results. One of the key informants, KI, stated that the portables ultrasound machines enable very clear images to view the fetus, thus making “It is easier to detect the abnormalities and pregnancy complications at an early stage”.

Thirteen point eight percent of respondents were in agreement, seventeen point six percent were in neutral, twenty-five point eight percent disagreed, and twelve point three percent strongly disagreed with the assertion that the imaging quality matched respondents' expectations for diagnosing pregnancy problems. It was found that the mean score of the portable ultrasound imaging was 3.97, the standard deviation score was 0.92 and the respondents attributed reliable performance of portable ultrasound imaging when detecting obstetric problems. This indicates that better quality imaging can be used for better risk

management from early pregnancy and increase in the confidence of prenatal diagnosis. This validates the findings of Maraci et al. (2022), who concluded that portable ultrasound scanners equipped with high-resolution images can enhance routine obstetric evaluations and achieve diagnostic standard as that of traditional ultrasound systems. Portable ultrasound machines will continue to be favored in obstetric care using Diffusion of Innovation Theory as it states that these machines will present some perceived relative benefits in obstetric care settings and therefore will be popular. This theory was supported by qualitative information. One KI responder had the following to say: "Healthcare providers are confident and clearly explain findings; and ultrasound images are good, and expecting mothers trust ultrasound findings.

111 (30.4%), 172 (47.1%), 39 (10.7%), 28 (7.7%) and 15 (4.1%) of the respondents agreed or strongly disagreed with the statement that portable ultrasound was able to correctly identify pregnancy-related problems. The scores for the statement have a mean of 3.92 and standard deviation of 0.97, indicating that people in general agree the diagnostic accuracy is good. This finding will help support the use of portable ultrasound for the early detection of pregnancy conditions, so that treatments can be undertaken before they deteriorate. This corroborates findings by Hall et al. (2021), who found that access to quality diagnostic imaging aided rural Tanzanians to earlier diagnose high-risk pregnancies and to improve referral rates. The findings of this research strengthen the Diffusion of Innovation Theory which believed a successful idea is likely to be accepted by the people and apply their theories. This conclusion was also supported by qualitative evidence. The majority of referrals are based on ultrasound / pregnancy test as it is a good discriminator of women who require specialist obstetric care (KI 4).

Concerning the statements "Participants said they believed the diagnostic data provided on the basis of the ultrasound," 117 participants (32.1%) strongly agreed, 174 participants (46.7%) agreed, 43 participants (11.8%) were indifferent, 20 participants (5.5%) were in disagreement

and 11 participants (3.1%) were in severe disagreement. The average ultrasound diagnostics' results trust was 4.00 with very low standard deviation of 0.89 points, the statement said. It indicates that reliability of diagnosis is not only a factor of trust for the patients in the advice of health care professionals but also enables mothers' compliance with health care plans. The findings dovetail with those of Maraci et al. (2022), who observed that consistency of diagnosis when using portable ultrasound services not only leads to greater patient trust in the care they receive, but also greater trust in their providers by the providers themselves. Qualitative results corroborated this view. KI 1 explained that: "Women do not tend to question the diagnosis we do trust the explanation from the healthcare providers and the result of the ultrasound.

When asked if it is stated that during prenatal visits, possible pregnancy problems were identified early, 109 respondents (29.9%) strongly agreed, 162 people (44.4%) agreed, 46 indifferently (12.6%), 30 disagreed (8.2%) and 18 strongly disagreed (4.9%). The mean score of responders was 3.85 with standard deviation of 1.03, indicating that overall, they believed that portable ultrasonography enabled the “early diagnosis” of problems with pregnancy. Favorable maternal outcomes can be more relevant, in other words, when diagnosis is timely, it lays the foundation for the earlier referral, clinical intervention and treatment. Liu et al. (2021) also discovered that portable ultrasonography greatly improved early detection of obstetric problems, leading to a decrease in maternal morbidity; our results are in line with theirs. The Diffusion of Innovation Theory states that positive outcomes that are evident persuade individuals to continue using the newly-adopted system of healthcare technologies. This finding was supported by qualitative findings. One of the ultrasound results is this, “Many healthy mothers have complications discovered in the ultrasound that allow us to refer them before having emergency complications.

117 respondents (32.1% of the total respondents) strongly agreed, 167 (45.8%) agreed, 41 (11.2%) were neutral, 26 (7.1%) disagreed, and 14 (3.8%) severely disagreed that healthcare

professionals used ultrasound results immediately to decide on maternity care. The mean score for the item was 3.95, SD 0.94, indicating that the results for the item had a clear impact on clinical therapy. Faster interpretation of the diagnostic results strengthens both improved customized maternity care and choices for referrals. This confirms what Hall et al. (2021) found: that primary healthcare centers in rural areas were able to enhance the delivery of maternity healthcare by quickly using ultrasonography data. The other findings of the qualitative research were: After immediate scanning, medical staff decide what is to be done: Does the mother need routine ANC or must they be referred to a higher-level hospital? Part 3. The numbers who strongly agreed (33.2% of all responses) and agreed (49.3%) that healthcare staff seemed confident when interpreting ultrasound information was n = 121 and n = 180, respectively. Interestingly, there was a high rating of importance attached to clinicians' interpretation of ultrasound results on the response to this statement with a mean score of 4.06 and standard deviation of 0.85. This analysis shows that better maternal health care is associated with and correlated with increased provider skill, and severity of provider skill is correlated with diagnostic confidence. This is consistent with Onyiego et al. (2021) who had also found that healthcare personnel's competency in ultrasound picture interpretation is much boosted through continuing professional training leading to an increased accuracy in diagnosis. This was confirmed by the qualitative findings. One participant responded “Confidence in interpretation of ultrasound images and in making clinical decisions have been greatly enhanced with continuous training”. (7 KI).

There were 114/312 (31.2%) responses that strongly agreed, 172/312 (47.1%) agreed, 42 (11.5%) were neutral, 24 (6.6%) disagreed and 13 (3.6%) very disagreed that the diagnoses and explanations were compatible with previous medical evaluations. The item's mean score of 3.96 with a standard deviation of 0.91 suggests that the results of the ultrasonography are consistent with those of other clinical evaluations. Portable ultrasound is capable of predicting

the diagnostic reliability and may be inferred to improve trust in maternal healthcare choices. This confirms the results of Maraci et al. (2022), who demonstrated that, in the hands of qualified operators, portable ultrasonography may provide diagnostic results that are on par with those of traditional obstetric imaging systems. One doctor confirmant told the trend: "The ultrasound findings almost always reflect the clinical examination, and therefore, our treatment choices are much more sure. Unit 4.

The results demonstrate the remarkable ability of quality imaging and accurate diagnostic interpretation to drastically improve early diagnosis of high-risk pregnancies, clinical decision-making by healthcare practitioners, referral networks, and maternal health outcomes. The findings indicate that provision of good quality imaging and diagnosis is key to improving maternity services to rural women who attend Malindi Sub-County Hospital.

4.3.3 Cost of Portable Obstetric Ultrasound Services and Maternal Health Outcomes

This section showcases the third aim of the research which is to establish the influence of cost of portable obstetric ultrasound services on the maternal health experienced by expectant mothers at Malindi Sub-County hospital found in Kilifi County. An analysis of maternal and fetal health outcomes, diagnostic turnaround times and the cost of these services is provided. In Table 8 you can see the findings that came from the 365 people that filled out the survey.

Table 8: Response on Cost of Portable Obstetric Ultrasound Services

n=365

Statements	SD % F	D % F	N % F	A % F	SA % F	Mean	Std Dvt
The fee for portable obstetric ultrasound services was reasonable.	22 (6.0)	36 (9.9)	49 (13.4)	157 (43.0)	101 (27.7)	3.73	1.07
The price of the portable ultrasound service matched the quality of care provided	18 (4.9)	30 (8.2)	46 (12.6)	164 (44.9)	107 (29.3)	3.85	1.00
I could easily afford to pay for portable ultrasound services during my pregnancy.	36 (9.9)	51 (14.0)	43 (11.8)	147 (40.3)	89 (24.4)	3.56	1.20
The cost of portable ultrasound services did not cause financial strain on my household	41 (11.2)	56 (15.3)	39 (10.7)	137 (37.5)	93 (25.5)	3.51	1.27
I spent more on portable ultrasound services than on other antenatal services.	28 (7.7)	43 (11.8)	56 (15.3)	147 (40.3)	91 (24.9)	3.63	1.13
Accessing portable ultrasound services significantly increased my antenatal care costs	25 (6.8)	39 (10.7)	51 (14.0)	152 (41.6)	98 (26.8)	3.71	1.09
High costs prevented me from accessing portable ultrasound services when I needed them.	30 (8.2)	46 (12.6)	41 (11.2)	142 (38.9)	106 (29.0)	3.68	1.19
If the portable ultrasound services were cheaper, I would have used them more frequently.	15 (4.1)	25 (6.8)	36 (9.9)	168 (46.0)	121 (33.2)	4.00	0.96
Composite Mean and Standard Deviation						**3.71**	**1.11**

Source: Field Data (2026)

According to the results presented in table 8, standard deviation of average cost of portable obstetric ultrasonography services is significantly associated with consumption of maternal health care services with a value of 1.11. This was a statement that was agreed to by a majority of the respondents.

Those percentages of respondents were asked whether or not the charge was reasonable for portable obstetric ultrasonography services: 101 (27.7%), 157 (43.1%), 49 (13.4%), 36 (9.9%) and 22 (6.0%). The mean is equal to 3.73 with a standard deviation of 1.07, meaning that majority agreed that the service fees were fair.

Affordability facilitates speedy prenatal diagnosis and stimulates the use of portable obstetric ultrasonography services. The results are in line with those of Logounov and Weber (2024), who found that public funding greatly improved pregnancy outcomes by increasing the uptake of obstetric ultrasonography services and decreasing cost obstacles. This finding aligns with the Diffusion of Innovation Theory (Rogers, 2003) which suggests that the people are more likely to adopt technologies if they believe this will have a positive impact on their wallets. There was qualitative evidence that backed with this conclusion. “Most mothers are agreeable for ultrasound examinations if the charges are not that high as they know its importance in monitoring pregnancy,” said KI 3.

The following percentages of respondents agreed with the statement: 107 (29.3%) “strongly agreed” with the statement, 164 (44.9%) “agreed” with the statement, 46 (12.6%) respondents were “neutral” on the statement, 30 (8.2%) respondents “disagreed” with the statement, and 18 (4.9%) respondents “strongly disagreed” with the statement that the price of portable obstetric ultrasonography services matched the level of treatment offered. The statement had an average score of 3.85 and a standard deviation of 1.00, indicating that respondents were satisfied with their monetary value. This implies that women had greater disposition towards the use of portable ultrasound services where they believed that the potential benefits were worthwhile paying for. This finding is consistent with earlier work by Amoakoh-Coleman et al. (2022) which reported that pregnant women in Ghana were more likely to access obstetric ultrasonography services when they felt they were getting value for money from the services. According to the Diffusion of invention Theory, the greater the perceived relative benefit of an invention, the more likely people are to adopt and continue using the new technology. In contrast, qualitative research identified that: “When mom is properly explained and diagnosed following the scan she's not as likely to grumble about the money that she feels good about the care that she receives.” (5 KI).

Of the 369 women who responded, 89 (24.4%) strongly agreed, 147 (40.3%) agreed, 43 (11.8%) were neutral, 51 (14.0%) disagreed and 36 (9.9%) strongly disagreed that they could afford portable ultrasound services during the course of their pregnancies. The mean score of 3.56 with standard deviation of 1.20 indicated the item with moderate degree of agreement. This means that cost was a problem for many pregnant women, particularly those of low income families, in accessing services, although many of the respondents were able to pay for the services. This corroborates the findings of Amoakoh-Coleman et al (2022) who identified budgetary limitations as a barrier to uptake of obstetric ultrasonography services that were recommended to low-income women. This theory was supported by qualitative data. “Some mothers delay ultrasound examinations, as they first have to raise funds to buy, particularly the vulnerable families,” said KI 2.

A total of 37.5% of the respondents (137) strongly agreed, 10.7% (39) were not sure, 15.3% (56) disagreed, and 11.2% (41) strongly disagreed about the system of portable ultrasound services not imposing excessive costs on household budgets. The lowest mean score (M = 3.51), standard deviation (SD = 1.27), of all the cost indicators assessed in the statement, was its score. While most respondents felt that ultrasound services were inexpensive, most of the respondents were still facing difficulties in their family income and economic status as is witnessed by the larger standard deviation as compared with the other results, indicating a larger variation in respondents' experiences. Hanson et al. (2025) discovered that obstetric ultrasonography was an costly prenatal service that many rural families in Kenya could not afford, resulting in delays in utilization of the recommended service. This confirmation from the results corresponds to. A key source shared that: "With many families living on lower incomes, sometimes they, rather than the expectant mother, cover the cost of sonography if it is necessary. A.I. 1.

The number of respondents who highly agreed was 91 (24.9%), agreed was 147 (40.3%), neutral was 56 (15.3%), disagreed was 43 (11.8%) and strongly disagreed was 28 (7.7%) that they paid more for the portable ultrasound services than for other prenatal treatments. The mean score was 3.63 with a standard deviation of 1.13, implying that ultrasound exams were perceived as having a relatively higher proportion of health care expenditures devoted to prenatal care. This may suggest that low income women have worse access to services as diagnostic imaging is a significant contributor to their out-of-pocket costs for maternity care. This validates the research of Hanson et al. (2025), which revealed diagnostic imaging as a major direct cost of the basic prenatal care received by women in rural areas of Kenya. This observation was further bolstered by qualitative results. One participant commented: "Some mothers believe that their ultrasound examination is one of the most costly aspects of the palmata" especially if repeated examinations are necessary. Unit 4.

A total of 152 respondents (41.6%) agreed, 98 (26.8%) strongly agreed, 51 (14.0%) were neutral, 39 (10.7%) disagreed, and 25 (6.8%) very disagreed with the assertion that prenatal care expenses were greatly raised due to availability to portable ultrasound services. With a mean score of 3.71 and a standard deviation of 1.09, this question clearly demonstrated that most people were in agreement that the expense of prenatal care was increased by ultrasound services. One might argue that women who actually use the recommended prenatal services accomplish this despite paying an extra cost, which indicates that portable ultrasonography may not encourage women to obtain complete prenatal care. This confirms the results of Ndikubwimana et al. (2026), who found that lowering user costs via community-based health insurance greatly enhanced adherence to prescribed prenatal care regimens and boosted usage of maternal diagnostic services. KI 3 provided an explanation regarding the availability of ultrasound services to support women to attend all recommended ANVs when subsidised or covered by insurance.

Regarding the respondents' level of agreement that the high cost of portable ultrasound services prevented them from obtaining the services when needed, responses ranged from 106 respondents (29.0%) strongly agreeing, 142 (38.9%) agreeing, 41 (11.2%) who were neutral, 46 (12.6%) who disagreed, and 30 (8.2%) who strongly disagreed. Financial constraints were also highlighted as a big barrier to the consumption of the service: The mean score was 3.68 and the standard deviation was 1.19. This indicates that despite this some pregnant women are still encountering various financial difficulties to get a timeliness diagnosis and referral which could affect their maternal health. This confirms the results of Amoakoh-Coleman et al. (2022) who reported that women with direct financial responsibility for obstetric ultrasound exams were less likely to undergo ultrasound exams recommended during pregnancy. This conclusion was further validated by the qualitative data. An important source responded: "Moms sometimes miss their scheduled ultrasound appointments just because they're unable to pay for the appointment at the exact time. KI 6.

Of the respondents, 121 (33.2%), 168 (46.0 %), 36 (9.9 %), 25 (6.8 %) and 15 (4.1 %) agreed that if portable ultrasound services were not so expensive they would have been used more. The highest mean score (M = 4.00, SD = 0.96) was from this statement which demonstrated that the most important cost factor was affordability. Poor maternal health outcomes due to the use of portable obstetric ultrasonography services appear to be a product of the high cost of the procedure, as based on the results of this study, it would seem that if the service were much cheaper, then more pregnant women would be using it and, therefore, maternal health outcomes would be better and diagnosis earlier. This result is in line with the conclusions made by Logounov and Weber (2024) and Ndikubwimana et al. (2026), who found that obstetric ultrasonography services are much more accessible when financial protection measures like community health insurance and public finance are in place. This theory was supported by

qualitative data. KI 7 states that "If ultrasound was offered on a discount or for free, almost every woman would opt in for the required ultrasounds.

Results from this study indicate that obstetric sonography services are a deterrent or facilitator to the use of portable obstetric sonography services by pregnant women according to cost of the service. A number of families had their ultrasound tests delayed or omitted because of the high cost, but many who responded considered the fees to be reasonable (and cost effective) based on the level of care received. By removing barriers to access to portable obstetric ultrasonography services, such as introduction of subsidies, mobilisation of public resources and an increase in health insurance coverage, the situation of rural women visiting Malindi Sub-County Hospital for health services could be enhanced.

4.3.4 Usability of the Portable Obstetric Ultrasound Services and Maternal Health Outcomes

The data about the study's fourth specific purpose are shown below. The purpose of this objective was to ascertain the level of usefulness of the portable obstetric ultrasound services to women in Malindi Sub-County hospital in Kilifi County when accessing labour and delivery services in the rural areas. Seeks to understand user experience, simplicity of use, and convenience in relation to acceptability, use, and overall maternal health outcomes and how these factors impact portable obstetric ultrasonography services. Table 9 shows the results that were achieved from the 365 participants questionnaires response.

Table 9: Response on Usability of the Portable Obstetric Ultrasound Services

n=365

Statements	SD % F	D % F	N % F	A % F	SA % F	Mean	Std Dvt
The healthcare providers operate the portable ultrasound machine efficiently.	10 (2.7)	20 (5.5)	36 (9.9)	177 (48.5)	122 (33.4)	4.04	0.87
The ultrasound procedure is performed smoothly without technical difficulties.	14 (3.8)	25 (6.8)	41 (11.2)	171 (46.8)	114 (31.2)	3.95	0.94
The images produced by the portable ultrasound are clear and easy for the provider to interpret.	12 (3.3)	22 (6.0)	39 (10.7)	172 (47.1)	120 (32.9)	4.00	0.90
The results from the portable ultrasound scan appear accurate and trustworthy.	11 (3.0)	20 (5.5)	43 (11.8)	174 (47.7)	117 (32.1)	4.00	0.89
The healthcare provider seemed well-trained in using the portable ultrasound equipment.	15 (4.1)	28 (7.7)	41 (11.2)	167 (45.8)	114 (31.2)	3.92	0.97
The healthcare providers can use the portable ultrasound device correctly.	10 (2.7)	18 (4.9)	37 (10.1)	180 (49.3)	120 (32.9)	4.04	0.85
The healthcare provider explains the ultrasound procedure clearly to patients.	18 (4.9)	30 (8.2)	46 (12.6)	162 (44.4)	109 (29.9)	3.85	1.03
The results of the ultrasound are explained by the healthcare provider to the expectant mothers.	16 (4.4)	28 (7.7)	43 (11.8)	168 (46.0)	110 (30.1)	3.89	0.98
Composite Mean and Standard Deviation						**3.97**	**0.92**

Source: Field Data (2026)

Results of Table 9 indicated that in general, the respondents found the Portable obstetric ultrasonography services provided by Malindi Sub-County Hospital very useful with a composite mean score of M = 3.97 and a standard deviation of SD = 0.92. The results indicate that the usability of the obstetric ultrasonography service, as a key element, is linked to its effectiveness that can bring about better clinical decisions, faster diagnosis and better maternal health.

The following percentages of respondents were asked about their opinions on the statement: 122 (33.4%) were in strong agreement, 177 (48.5%) were in agreement, 36 (9.9%) were neutral, 20 (5.5%) were in disagreement, and 10 (2.7%) were in strong disagreement. The

statement with a mean score of 4.04 and SD score of 0.87 clearly indicates that there is an overall positive perception about the skill of healthcare workers with the use of portable ultrasound machine. This is a result that provider competency is a predictor of efficiency of the services provided and that this enhances the quality of maternal healthcare delivery. Findings are in line with those of Packet et al. (2024), who found that healthcare personnel' confidence and competence to handle portable ultrasound machines was much enhanced with competency-based training, leading to better obstetric evaluation.

This discovery lends credence to the Diffusion of Innovation Theory, which states that people are more likely to accept and make good use of innovations if they believe they will be easy to use, compatible with existing systems, and have comparable advantages. This was supported by the qualitative analysis results. Most of staff received good training from K1 for use of portable ultrasound and staff can use the ultrasound machines efficiently during routine antenatal clinics", K1 clarified.

Responding to the question on whether an ultrasound operation goes off smoothly and doesn't experience any technical problems, 114 (31.2%) respondents were in full agreement, 171 (46.8%) in partial agreement, 41 (11.2%) were indifferent, 25 (6.8%) in strong disagreement and 14 (3.8%) in no agreement at all. The mean score is 3.95 with SD value of 0.94, thus means that overall respondents reported a low number of technical difficulties in performing ultrasonography procedures. This indicates a possible relationship between technology and delivery of maternal health services, and the reduction of diagnostic delay. This validates De Souza's (2025) findings that portable ultrasound scanners are easy to use, reduce wait times for patients and improve the ability for prenate care clinicians to make informed decisions. Per the Diffusion of Innovation Theory a new medical technology might become mainstream in no time at all, if it is perceived as easy and useful. Important Source K3 provided this affirmation

by saying: *"Technical interruptions are now rare because the portable machines are easy to use and require minimal preparation before scanning patients."*

120 (32.9%), 172 (47.1%), 39 (10.7%), 22 (6.0%), 12 (3.3%) agreed to the following percentages: The photos obtained with the portable ultrasound were clear and easy for the provider to interpret. The results indicated that the mean for the diagnostic pictures the equipment produced is 4.00 and the standard deviation is 0.90, which indicates high-quality diagnostic pictures. Clarity of images appears to help to forecast diagnostic confidence and to ease in an early discovery of the problems affiliated to pregnancy. The results are in line with those of Abawollo et al. (2022), who found that, despite difficulties in implementation, healthcare professionals' capacity to identify high-risk pregnancies and support prompt referrals was much enhanced by portable obstetric ultrasonography. Perceived advantages is a major notion in the Health Belief Model, which explains why people are more inclined to embrace and make use of health-related interventions when they think they will help them with their health issues. This study is in line with this theory. This was complemented by the qualitative data. A key informant, K2, said that: *"The images produced by the portable ultrasound are generally very clear, making it easier for clinicians to identify complications early."*

The findings of the portable ultrasound scan seem reliable and trustworthy – 117 respondents were very much in agreement (32.1% of total), 174 with the agreement (47.7% of total), 43 were at the neutral position (11.8% of total), 20 disagreed (5.5%) and 11 severely disagreed (4.0%). The mean score for this statement, M = 4.00; SD = 0.89, showed that there was a high level of confidence for the diagnostic conclusions made by portable ultrasonography services. When healthcare providers have confidence in the correctness of their diagnoses, they can make more informed choices and deliver the appropriate care to mothers. This validates the work conducted by Santos et al (2021) which concluded that besides affecting the choice of

referral, there was an improvement in early diagnosis of maternal problems, due to competence in using portable ultrasonography devices. According to the Diffusion of Innovation Theory, the benefits of an innovation and how well it fits with current practice will influence the degree of acceptance and continued usage, providing greater support for the conclusion. This evaluation was confirmed by the important Informant K4 who gave the following explanation: *"Healthcare providers trust the ultrasound findings because they are consistent with the clinical signs observed during patient assessment."*

One hundred fourteen (31.2% total) highly agreed, 167 (45.8% total) agreed, 41 (11.2%) were neutral, 28 (7.7% total) disagreed, and 15 (4.1% total) severely disagreed that healthcare professional seemed to know enough to use the portable ultrasound equipment. Respondents disagreed that healthcare personnel did not possess adequate technical skill, with the mean score for M = 3.92 and SD = 0.97. This study provides support for the notion that continued training of health care providers leads to more efficient and convenient delivery of maternal care, as well as increases use of transportable ultrasound care. This aligns with the study of Kamau (2025), which revealed that the level of competency among the healthcare personnel in portable ultrasound operation had improved and in addition, the clinical efficiency also improved after undergoing specialized training. The Diffusion of Innovation (DOI) theory suggest that the knowledge and skills users possess, and their ability to integrate the innovation into their daily use affect the adoption and effective use of the innovation. Key Informant K1 provided evidence in support of this view by saying: *"Regular refresher training has greatly improved staff confidence and competence in operating portable ultrasound machines."*

120 respondents (32.9%) agreed completely with the statement that healthcare workers are able to effectively use the portable ultrasound devices. Of the 180 respondents (49.3%), 37 (10.1%) were unsure, 18 (4.9%) were opposed, and 10 (2.7%) were vehemently opposed. The item's high mean score (M = 4.04, SD = 0.85) suggests that healthcare professionals have a lot of

confidence in their abilities to use the technology correctly. One more discovery is that the right use of portable ultrasound contributes to better and correct diagnosis and better maternity treatment. This confirms what Packet et al. (2024) found: that healthcare personnel' competency-based training greatly improves the accuracy of their obstetric ultrasound exams. The finding is consistent with the adoption/absorption concept of Diffusion of invention Theory, which suggests that the more people get to know something new and are familiar with it, the more they are predisposed to adopting and practicing the technology in their day-to-day life. Source K5 made an observation: *"Most clinicians are now comfortable using portable ultrasound because they have acquired sufficient practical experience over time."*

The percentage of respondents who agreed with the item "Patients are provided with a clear explanation of how ultrasound is performed" were: 29.9%, 44.4%, 12.6%, 8.2%, 4.9%. The mean score (M = 3.85, SD = 1.03) for the item measuring adequate informedness about ultrasound techniques by the pregnant women's health care providers indicated that they were well-informed. This evidence suggests that good communication by providers can result in patients: The results are in line with those of De Souza (2025), who reported an improvement in clinical care and communication between patients and providers after using portable ultrasound services that were easy to use. The Health Belief Model provides an additional explanation for this result via its notion of signals to action. This model is used to suggest that the presentation of information and reassurance to individuals can help to improve their understanding and acceptance of health interventions. In support of this conclusion Key Informant K2 made the following observation: *"Before conducting the scan, healthcare providers explain the purpose of the procedure and reassure mothers, making them more comfortable during the examination."*

One respondent (0.3%) was very much in agreement, 168 respondents (46.0%) were indifferent and 28 respondents (7.7%) disagreed that the healthcare provider discusses the ultrasound results with the expectant mothers; and 16 respondents (4.4%) strongly disagreed. On the whole, the mean score of the item was 3.89 SD 0.98 indicating that respondents felt they were informed enough to understand the results of their ultrasound. This translates to better patient care when their results are effectively communicated, thereby helping patients with better adherence to medical counselings, expanding their understandings about health and enhancing their health status. These findings align with that of Kamau (2025), who established that good communication between a health care provider and patient increase access to maternal health services for pregnant women. This discovery is accredited by the Diffusion of idea Theory that emphasizes the role of good communication and human contacts in helping to grow the understanding, acceptance, and adoption of an idea. This was confirmed by K3, a key informant, who explained: *"After every scan, we explain the findings to the mothers and advise them on the next steps depending on the results."*

The results showed that the healthcare professionals' knowledge, equipment operation, correct ultrasound interpretation, precise diagnostic results, and good communication were the reasons why the portable obstetric ultrasonography services were considered very practical. These findings suggest greater usability leads to better quality of maternity care, as it enables more informed clinical decision making, better patient-provider communication and speedier diagnosis.

4.3.5 Maternal Health Outcomes among Rural Women in Kilifi County

Results of maternal health outcomes among rural Kilifi County women (the study's dependent variable) are presented in this section. increased prenatal care attendance, better birth outcomes, increased mother and fetal wellbeing, and faster diagnosis of problems are some of the ways

in which portable obstetric ultrasonography services impact pregnant women's overall health. Table 10 displays the findings that were obtained from 365 participants' questionnaire replies.

Table 10: Response on Maternal Health Outcomes

n=365

Statements	SD % F	D % F	N % F	A % F	SA % F	Mean	Std Dvt
Expectant mothers are required to attend at least eight antenatal care visits during pregnancy.	13 (3.6)	23 (6.3)	40 (11.0)	178 (48.8)	111 (30.4)	3.96	0.92
There are skilled health professionals to assist expectant mothers during childbirth.	16 (4.4)	28 (7.7)	43 (11.8)	172 (47.1)	106 (29.0)	3.87	0.99
Expectant mothers receive postnatal care within 72 hours after delivery.	18 (4.9)	30 (8.2)	45 (12.3)	164 (44.9)	108 (29.6)	3.84	1.03
I consistently take iron and folic acid supplements as prescribed during pregnancy.	11 (3.0)	21 (5.8)	41 (11.2)	178 (48.8)	114 (31.2)	4.01	0.88
I had a clear plan for delivery, including transportation and healthcare facility selection.	17 (4.7)	27 (7.4)	47 (12.9)	171 (46.8)	103 (28.2)	3.86	1.00
I am knowledgeable about danger signs to watch for during pregnancy and childbirth.	15 (4.1)	25 (6.8)	43 (11.8)	174 (47.7)	108 (29.6)	3.92	0.95
I was satisfied with the quality of the maternal healthcare services I received.	20 (5.5)	32 (8.8)	46 (12.6)	162 (44.4)	105 (28.8)	3.79	1.07
There is timely access to emergency obstetric and neonatal care services when needed.	22 (6.0)	36 (9.9)	51 (14.0)	154 (42.2)	102 (27.9)	3.74	1.13
Composite Mean and Standard Deviation						**3.90**	**0.97**

Source: Field Data (2026)

The results indicated that generally, respondents felt that women with prenatal care services at Malindi Sub-County Hospital were experiencing positive maternal health outcomes as evidenced in Table 10. This composite mean was 3.90 with a standard deviation of .97. The low standard deviation suggests that respondents' assessments of the many indices of maternal health outcomes are consistent.

The number of respondents who agreed was: 111 (30.4%), 178 (48.8%), 40 (11.0%), 23 (6.3%), and 13 (3.6%) to rate the statement, "Pregnant women must legally attend at least 8 prenatal visits. Most of the respondents had a positive mean (M = 3.96,SD = 0.92), and knew the importance of attending scheduled prenatal care. Frequent ANC use is key both to diagnosis of pregnancy complications at an early stage, and to excellent maternal health outcomes. Results support the World Health Organization (2022) recommendations of at least 8 antenatal visits in the support of the mother and baby. This validates the Health Belief Model that people are more likely to use preventative health services when they believe that it makes good use of their time and when they are provided with the appropriate incentives to participate. In line with this reading, Informant K1 provided the following: *"Most mothers now understand the importance of attending all recommended antenatal visits because healthcare providers continuously educate them during every clinic appointment."*

The response rates that agreed with trained health professionals available to assist pregnant women during childbirth were as follows: 106 (29.0%), 172 (47.1 %), 43 (11.8 %) and 28 (7.7 %), and 16 (4.4 %). This question has a mean score of 3.87 and a standard deviation of 0.99, showing that majority were of the opinion that experienced delivery attendants were easily available. This means that women's problems and births are often fewer and safer the more accessible the healthcare professionals. This aligns with earlier studies which indicates competent delivery attendance is a very important factor in increasing mother survival rates (2023, World Health Organization). The HBM suggests that women who have access to skilled health care providers will be more confident in the efficacy and safety of maternal health services. This in turn, motivates them to get professional medical attention as needed. In this regard, the key informant K2 said: *"Most deliveries are now conducted by trained nurses and midwives, which has greatly reduced delivery-related complications."*

A total of 108 respondents (29.6%) were very much in agreement, 164 (44.9%) were indifferent, 30 (8.2%) were in disagreement and 18 (4.9%) were in extreme disagreement that pregnant women receive postnatal care within 72 hours after birth. Results showed that the majority of moms had postpartum care quickly after giving delivery (M = 3.84, SD = 1.03). From this study, it may be inferred that by providing early follow-up to mothers during the postnatal period, early detection and treatment of problems in the postpartum period may also improve the maternal health outcomes. This is consistent with the previous statement made by the WHO (2022), that, for optimal maternity care, the prompt provision of postpartum care services is essential. Furthermore, this aligns with the Health Belief Model in which the benefits (perceived or not) and cues to action (perceived or not) influence women's uptake and sustained use of recommended maternal health care. Key Informant K3 commented in support of this view that: *"Mothers are routinely reviewed within the first few days after delivery to identify any complications and provide necessary support."*

The amount of respondents reporting that respondents always take folic acid and iron supplements as advised during pregnancy was as follows: very much in agreement 114 (31.2%), somewhat in agreement 178 (48.8%), ambivalent 41 (11.2%), in disagreement 21 (5.7%) and in extreme disagreement 11 (3.2%). This statement has a mean score of 4.01 and a SD of 0.88 indicating that supplements is being taken according to prescription. Women of reproductive age seem to have awareness of the importance of iron and folic acid supplementation to prevent anaemia and for a safe pregnancy. This finding gives credit to a statement made by the World Health Organization (2020) suggesting that supplementation of iron and folic acid during pregnancy should be standard. This finding is in line with the Health Belief Model, which states that people are more inclined to follow health recommendations when they can see the direct positive effects on their health. Key Informant K4 commented in support of this conclusion: *"Most mothers adhere to iron and folic acid supplements because*

healthcare workers continuously educate them about their importance during antenatal clinics."

One hundred three (28.2%) were very much in agreement, 171 (46.8%) were ambiguous, and 27 (7.4%) were in disagreement, with 17 (4.7%) strongly disagreeing that they had a clear plan for delivery (including mode of transport and healthcare facility chosen). The high mean (M = 3.86, SD = 1.00) for the statement indicated that a large number of the respondents were involved in birth preparation. This implies that in case of an obstetric emergency proper preparation well in advance will assure the availability of a competent delivery service promptly. The results are in line with those of the World Health Organization (2023), which has highlighted birth preparation as a key method to enhance maternal health outcomes. This is corroborated by Key Informant K5: "During the ante-natal visits mothers are encouraged to make arrangements for their delivery such as transportation, the health facility where they plan to give birth etc".

The following percentages of the respondents were asked about their knowledge regarding danger indicators when a child is in labour and during her pregnancy: 108 (29.6%), 174 (47.7%), 43 (11.8%), 25 (6.8%) and 15 (4.1%). The mean of the statement (M = 3.92, SD = 0.95) suggested a high percentage of knowledge of obstetric risk indicators. If a pregnant woman receives health education while visiting her doctor during her pregnancy, she has a better chance of identifying a situation and seeking medical assistance promptly if a problem should occur. This finding supports the Health Belief Model, which provides that the more individuals are educated about the potential health risks the more likely they are to seek medical care when needed. The observation validates this finding as reported by the Key Informant K2, "Health education session has boosted awareness to mothers on dangers of pregnancy thus they seek medical help on time when danger is encountered.

A total of 105 respondents (28.8%) strongly agreed, 162 (44.4%) agreed, 46 (12.6%) were neutral, 32 (8.8%) disagreed and 20 (5.5%) strongly disagreed the respondents were satisfied with the quality of maternal healthcare services received. Majority of the respondents were satisfied with the Maternal health care services they got during their pregnancy with mean score of 3.79 out of 5 and standard deviation of 1.07. The finding points to patients feeling more confident with quality care and having greater potential to use maternal health services. According to the Diffusion of Innovation Theory, which postulates that an innovation's perceived relative benefit might impact its adoption and ongoing use, the conclusion is in line with this theory. Therefore, it's crucial to offer comprehensive prenatal care — meaning portable ultrasounds plus the follow up — such that mothers can realize the worth of the service and use it more readily. Key Informant K1 provided evidence in support of this view by saying: *"Most mothers express satisfaction because they receive comprehensive antenatal care, including ultrasound services and continuous follow-up."*

When asked whether or not obstetric and newborn services are available when needed, the overwhelmingly majority (102 – 27.9%) agreed. A smaller percentage (51, or 14.0%) were unsure, while 36, or 9.9%, disagreed and 22, or 6.0%, severely disagreed. While most of the respondents agreed with the statement, there was the lowest mean score (M = 3.74, SD = 1.13) for measures of maternal health outcomes. This shows that emergency obstetric treatment is readily available, but it could also mean that there are some delays, possibly due to the limitations on or problems with the referral system, transportation, or the health system. Despite progress in maternal health care, the World Health Organization (2023) indicates that rural areas have challenges to provide prompt access to obstetric emergency care. This finding is in line with their observations. This was further corroborated by key informant K3 who stated that, "While there are emergency services available, referrals may be delayed due to transportation problems or the lack of ambulances.

Among the respondents, high frequencies of prenatal care attendance, trained birth attendants, prompt postnatal care, folic acid, iron supplementation, birth preparation, knowledge of pregnancy risk factors and satisfaction with maternal health services indicate good maternal health outcomes on most indicators. According to these results, maternal health outcomes are greatly enhanced when high-quality maternal healthcare services, such as portable obstetric ultrasonography, are made available.

4.4 Inferential Statistics

Inferential statistics were used to explore the relationships between portable obstetric ultrasonography services and the maternal health outcomes. To assess the individual and combined effects of accessibility, quality of imaging/diagnosis, cost and use of portable obstetric ultrasound services on maternal health outcomes, Pearson-product moment correlation analysis was used to determine the strength and direction of the correlation between the study variables. Further, we performed several linear regressions to achieve further results narrowing.

4.4.1 Pearson Product-Moment Correlation Analysis

To find out how the independent factors related to the maternal health outcomes and in what way, we used Pearson Product-Moment Correlation Analysis. The results are shown in Table 11.

Table 11: Pearson Correlation Matrix

Variables	1	2	3	4	5
1. Accessibility	1				
2. Quality of Imaging and Diagnosis	.684**	1			
3. Cost	.571**	.618**	1		
4. Usability	.649**	.732**	.596**	1	
5. Maternal Health Outcomes	.701**	.768**	.583**	.739**	1

Note: Correlation is significant at the 0.01 level (2-tailed).

n = 365

Table 11 showed that all the factors were positively associated with country level maternal health outcomes and were statistically significant (p values < 0.01). Accessibility of portable obstetric ultrasonography service in Sri Lankan districts showed high positive correlation with maternal health outcomes ($r = 0.701$, $p < 0.001$) indicating that better maternal health outcomes are associated with improved accessibility of services. Similarly, the highest positive correlation with maternal health outcomes was with imaging and diagnostic quality ($r = 0.768$, $P < .001$) indicating that high quality and accuracy of imaging has significant positive impacts on maternal health outcomes.

Affordable ultrasound services boost use and, as a result, maternal health outcomes, as shown by a somewhat favorable and statistically significant link between the cost of portable obstetric ultrasound services and maternal health outcomes ($r = 0.583$, $p < 0.001$). Likewise, high positive correlation results were the same for the usability of the portable obstetric ultrasonography services and maternal health outcomes ($r = 0.739$, $p < 0.001$), thus the use of portable ultrasound devices by healthcare workers and the skill to use them is related to better maternal health outcomes.

There are strong associations between improved maternal health outcomes and the following factors: cost of portable obstetric ultrasonography, usability, accessibility, and imaging and diagnostic quality. Multiple regression analysis was employed and the predictive effect of each variable was determined after the effects of the other variables were statistically accounted for because correlation is not necessarily causation.

4.4.2 Multiple Linear Regression Analysis

Multiple linear regression analysis was performed to understand the effect of portable obstetric ultrasonography services on maternal health outcomes. Accessibility, imaging and diagnostic quality, cost and usability were the variables.

Model Summary

Table 12: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.854	.729	.726	0.386

Constant predictors are Accessibility, Cost, Quality of Imaging and Diagnosis, Usability.

The regression model was able to account for much of the data, having an R-value of 0.854. The combined explanatory power of accessibility, diagnostic quality, affordability, and the usability of portable obstetric ultrasonography services is $R^2 = 0.729$ or 72.9% of the variance in maternal health outcomes. The remaining 27.1% can be interpreted as being due to variables not addressed in the model.

ANOVA Results

Table 13: ANOVA

Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	145.263	4	36.316	243.781	.000
Residual	53.628	360	0.149		
Total	**198.891**	**364**			

Based on ANOVA results, $F(4,360) = 243.781$, $p < 0.001$ is statistically significant regression model. Together the four predictor factors can, therefore, explain maternal health outcomes very well.

Regression Coefficients

Table 14: Regression Coefficients

Variable	**Unstandardized B**	**Std. Error**	**Standardized Beta**	**t**	**Sig.**
(Constant)	0.412	0.167	—	2.467	.014
Accessibility	0.248	0.041	0.261	6.049	.000
Quality of Imaging and Diagnosis	0.337	0.044	0.369	7.673	.000
Cost	0.132	0.036	0.143	3.667	.000
Usability	0.291	0.043	0.318	6.767	.000

Health Outcomes as a Dependent Variable.Health Outcomes as a Dependent Variable (Moms).

The regression results indicated that all four independent factors were significant at a 0.05 level of significance to the maternal health outcome. Higher quality of imaging and diagnostics was suggested to be related to the highest improvements on maternal health, as it had the greatest effect ($\beta = 0.369$, $p < 0.001$).

A usable portable obstetric ultrasound service was the second most important predictor ($\beta = 0.318$, $p<0.001$), suggesting that health care professionals using the portable ultrasound services successfully will be important mechanisms to improve maternal health care. This was positively correlated with increased availability to portable ultrasound services, for which there was also a positive impact on this outcome ($\beta = 0.261$, $p < 0.001$). There was a high impact of affordability, as cost – the least reliable predictor – was also statistically significant ($\beta = 0.143$, $p < 0.001$).

Therefore the regression equation obtained is:

$$Y=0.412+0.248X_1+0.337X_2+0.132X_3+0.291X_4$$

The regression results show that for every unit increase in accessibility, imaging & diagnostics quality, cost (affordability), and usability, maternal health outcomes would score 0.248, 0.337, 0.132, and 0.291 respectively, better, with other factors controlled. Factors related to imaging and diagnostic quality had the largest impact on maternal health outcomes followed by accessibility, affordability, and usability. The results of this study reveal that providing better quality, usability, accessibility and cost of portable obstetric ultrasound services has a favourable and significant association with maternal health outcomes for women going to Malindi Sub-County Hospital.

4.5 Limitations of Findings

In rural women in Kilifi County's Malindi Sub-County Hospital, this research found that access to portable obstetric ultrasonography services greatly affects maternal health outcomes. When assessing these findings, it is important to recognize the measures taken to minimize the methodological and contextual restrictions.

First, given the sensitive nature of maternal health care use and satisfaction, there may have been recollection or social desirability biases related to respondents' self-reports on the subject. Some of the respondents may have been exaggerating the positive and minimizing the negative in explaining their experiences. To overcome this, well-structured and easily understandable questionnaires were used to reduce leading questions and ambiguity. Furthermore, the participants were ensured anonymity and secrecy hence they were comfortable enough to answer the questions truthfully and the tendency to manipulate answers was reduced.

Perhaps the second problem is that it was a cross-sectional study, and although the sample size was large, the researchers attempted to add credibility to their conclusions by using mixed-methods triangulation (Creswell, 2003) they were unable to demonstrate any causal relationships. This does not imply that the association between maternal-health outcomes and portable obstetric ultrasonography use should be viewed as causal. It was addressed by inclusion of qualitative data from key informant interviews to provide contextual explanations for the statistical association; however, it was a restriction of the study. Multiple linear regression analysis was performed on the observed relationship further controlling for important predictor factors, strengthening both the reliability and internal validity of the observed relationship.

Thirdly, the results may not apply to other areas with varied health system capacity, geographical circumstances, and socioeconomic traits since the research only included one sub-county hospital catchment area. These findings may not be generalizable due to variations in

ultrasonography service availability, staffing and infrastructure among counties. To overcome this restriction and improve representativeness, the study ensured that the participants were drawn from a range of different rural settings in the catchment area. Understanding the results in the context of well-known theories including the Health Belief Model and the Diffusion of Innovation Theory also helped establish the results as applicable to other rural regions, whose maternal health needs mirror those of the village examined in the study.

Finally, although fit of the regression model to the maternal health outcomes was good (R^2 = 0.729), it should be noted that a considerable amount of variation was not accounted for, possibly because of factors not considered in this study. These can range from cultural norms to decision-making processes in families, to the influence of partners and to systemic barriers in health care. This limitation was reduced by incorporating qualitative information from key informants, allowing for better understanding of and exposure to some of these environmental factors. Furthermore, the model's explanatory capability was further strengthened by incorporating other relevant predictor variables (accessibility, quality imaging, affordability and usability) which reduced omitted variable bias.

4.6 Chapter Summary

This section detailed the results of the research that looked at how rural women who went to Malindi Sub-County Hospital fared when they received portable obstetric ultrasonography services. Descriptive data overall indicated that respondents had a high level of satisfaction with the service with regard to accessibility, affordability, diagnostic quality, and ease of use. Inferential analysis found that the accessibility, imaging and diagnostics quality, affordability and usability were the strongest factors that predicted maternal health outcomes. The conclusions, findings, recommendations and ideas for further study are summarized in the next chapter.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.0 Introduction

This chapter summarizes the findings of the study and discusses the results and implications of the study both theoretically and practically, conclusions, recommendations, areas of further study, and the study's contribution to the body of knowledge.

5.1 Summary of Findings

The key results of the research as per their objectives are summarized here. The curators in Malindi Sub County in this study aimed at addressing the following queries: What is the rural women's perception on accessibility, quality, price and usefulness of portable obstetric ultrasonography services? Further they wanted to know the impact of these services for early detection. A combination of descriptive and inferential results make up the summary, with the study's findings taking center stage.

5.1.1 Portable Obstetric Ultrasound Services Accessibility and Maternal Health Outcomes

Results revealed that in Malindi Sub-County hospital, when eligibility for portable obstetric ultrasonography was higher, the health situation for rural women was better (M = 3.80, SD = 1.02). Measures of geographical accessibility and awareness of service points indicated that the majority of respondents agreed that ultrasound services were in close proximity to home, and that they knew what services were available when pregnant with a child. There were fewer barriers leading to an increase in attendance for antenatal care. In addition to the high uptake of this service, the study identified that most women had at least one portable ultrasound scan while pregnant, as well as a high demand from healthcare providers for scanning, which contributed to its increased use. However, several interviewees voiced concerns with the availability and cost of mobile ultrasound services, which they thought would be obstacles to

use. But another complaint raised was the wait time for the customer, indicating that operational delays would sometimes make it difficult to access. With most of the services, clinics were easily able to access these services and they were able to get them when needed but some services were delayed or even unavailable at certain points of time hence disrupting the continuity. The data overall suggest that having physicians recommend the service, being closer to the facility and being aware of it, encourage participation in maternal health care but that the cost and waiting time remains great barriers to the optimal benefits in maternal health care.

5.1.2 Quality Imaging and Diagnostics on the Early Detection and Maternal Health Outcomes

In its analysis, it revealed that good imaging and diagnostic performance was important in the good outcome of maternal health services, to women attending Malindi Sub-County hospital. Overall the opinion of the responders was favorable and they felt that the diagnostic outputs were clear enough to allow excellent clinical interpretation, and that the ultrasound pictures were clear, accurate and reliable. Given the very high level of agreement, the technology may be useful for both operational and clinical purposes to improve decisions around prenatal care. It was found that the use of portable ultrasonography is associated with better maternal care planning, more rapid diagnosis of problems and more efficient referral systems, thus, it is important in maternal healthcare.

The study too revealed that professionals have great trust in ultrasound diagnosis, which was supported by the results when doctors and nurses attempted to interpret ultrasound findings. This trust was related to the positive advising of received and adopted suggested maternal behaviours. High agreement of the ultrasound findings with medical ones gave credit to the reliability of ultrasonography as a diagnostic method. Speaking of the survey, while these

results are encouraging, the survey revealed there are some areas that need improvement, particularly around early detection of issues and dissemination of diagnostic data.

5.1.3 Cost of Portable Obstetric Ultrasound Services and Maternal Health Outcomes

An in-depth study in Malindi Sub-County Hospital in Baragaba County, specifically in a remote location, revealed that women's use of maternal health care services is greatly influenced by the fee charged for portable obstetric ultrasonography. Many respondents believed that these rates were reasonable and related to the service they had received, but the results highlighted that for many families there was a significant difference in how affordable the prices were. The consensus stated women were satisfied with the price of the service when it came to better pregnancy monitoring and diagnostics. But financial constraints continued to affect the continuity of services offered during prenatal periods.

The research shows that costs present a practical barrier in accessing maternal health. Many respondents spoke about ultrasound available as part of prenatal care and how this adds to the total cost and may strain family resources. This meant that some women, especially those from the lower socioeconomic groups, where she had to consider other basic needs such as feeding the family, were delayed in getting their scans and, at times, were not able to receive them at all. Even in the face of these limitations, there was consensus that lowering the price of ultrasound services would allow more people to use them and would allow them to use them more effectively.

5.1.4 Usability of the Portable Obstetric Ultrasound Services and Maternal Health Outcomes

The study revealed that portable obstetric ultrasonography was highly useful to the rural women and was well integrated in maternal health care provision in Malindi Sub-County Hospital. It was a consensus among respondents that services are user friendly, technically stable and performed by expert health care providers. The results have shown that the providers

very efficient on operation on the ultrasound equipment and have excellent technical abilities. This enables them to offer patients trust and smooth services. Once ultrasound imaging was believed to be diagnostic and accurate, as most people believed it gave a clear and trusted diagnosis, there was a rise in clinical decision making and a rise in mothers' confidence in prenatal care services.

The study also showed that the healthcare administrators, technologists, and operators could operate and use the ultrasound machines, indicating a promising reliability and effectiveness of the service. A few problems in informing patients procedure and findings but as a whole informative communication was considered good. To fully understand findings from scanning several of the respondents commented on the need for increased depth and frequency of communication. The findings revealed however, that in order for portable obstetric ultrasonography to be widely adopted, accepted and effective in enhancing maternal health outcomes, provider competence, technological performance and diagnostic output should be good. Though there were a few minor issues.

5.2 Contribution to Knowledge

This study contributes to the available literature by presenting empirical data on the impact of the portable obstetric ultrasonography services amidst the rural women visiting Malindi Sub-County Hospital in Kilifi County in Kenya. Unlike the previous studies which have considered each of these qualities – diagnostic quality, cost, usability, and accessibility – separately, the present study integrates and allows all four qualities to be displayed within the same theoretical context, and illustrates their impact on the health of mothers.

Research indicates that the most important factor in maternal health outcomes, next to factors 1-3 listed above is quality of imaging and diagnosis. A lack of empirical studies exists on service delivery with portable ultrasound machines, and for this reason alone, this study is valuable for adding to the body of knowledge, in addition to providing information pertinent

to a Kenyan rural site. Quantitative and qualitative data together provide a comprehensive picture of the potential impact of mobile obstetric ultrasound services such as early problem detection during pregnancy, improved referral practice, increased maternal healthcare service use and enhanced clinical decision-making.

This research extends existing literature in the field of Development Studies with respect to how the appropriate health technology can contribute to the development of health systems, rural health service provision, and the eradication of inequities in the access to healthcare. Therefore, it can be concluded that the findings contribute to the overall knowledge and could be used to direct future research in the provision of maternal health services in the underserved technology enhanced regions. This is relevant for health policy, resource allocation and service delivery and other areas.

5.3 Theoretical Implication of the Study

The findings of this study have many theoretical and developmental implications. Findings suggest that the Health Belief Model (HBM) and Diffusion of Innovation Theory (DOI) could be applied to explain the effects of portable obstetric ultrasonography services on the adoption of these services and maternal health care. The HBM is based on the assumption that the more a woman thinks there are less barriers to utilizing a portable obstetric ultrasound service and more benefits, the more likely she will feel to utilize such services. However, limited resources, as well as occasional delays in treatment, continued to make optimum use less probable, as the HBM assessment indicates the relative importance of perceived advantages and obstacles affects health-seeking behavior. Hanson et al. (2025) reported similar results, which emphasises the importance of eliminating financial and structural barriers to encourage the use of maternal health services.

The results further confirm the validity of the DIT model as adoption of portable obstetric ultrasonography services is related to its perceived accuracy, ease of use, reliability and

compatibility with existing maternal health care practices. Diagnostic quality and usability is a plus, as was noted by healthcare professionals and pregnant women's willingness to accept technologies that offer evident therapeutic benefits. At the same time, it suggests that innovation in healthcare is taking place in the context of socioeconomic concerns — an issue when thinking about affordability. This aligns with recent research by Logounov and Weber (2024) and Kamau (2025) which revealed that portable diagnostics technology effectiveness goes beyond just the technology itself and requires affordable delivery models, educated personnel and health-supporting health systems.

5.3 Implication of the Study Findings in Development Studies

The conclusions of the study show that a mobile obstetric ultrasound service can help positively influence maternal health, including better prenatal care service utilization, easier clinical decision-making, and better diagnosis of the problem. In order to improve maternal health systems and decrease unnecessary maternal and newborn mortality, the World Health Organization (WHO) (2023) states that access to critical diagnostic tools is crucial.

Beyond child health improvements, many other potential impacts to development can be anticipated from better maternal health, the study states. These include lower maternal and baby mortality rates; healthier families and more family productivity. The United Nations (2024) underscored the importance of investments in maternal health care to support the goals of sustainable development which focus on promoting excellence in health, gender equality and poverty reduction.

Findings also indicate the truth that there is under-utilisation of portable obstetric ultrasonography services, due to issues such as cost and access. Hence, all three need to be addressed: maternity packages to help ease the poverty costs of childbirth, better health facilities in rural areas, and financing packages. To lessen health disparities in neglected areas, the World Bank (2025) says that primary health care must get sufficient funding and attention.

Human capital is crucial for improving maternal health care, according to the study's last point. Healthcare providers' competence and aptitude to use ultrasonography effectively was pivotal to portable obstetric ultrasound services. Maximizing the effect of health technology and improving the quality of maternal health care services need continual training of health professionals, according to the World Health Organization (2024).

5.4 Conclusion

The research findings indicated that the use of Portable Obstetric Ultrasonography services in Malindi Sub-County are highly beneficial to rural women and the roles that the services can play are differently sketched based on the aspect of maternal health care services being provided.

The findings reveal that the vast majority of pregnant women have convenient access to portable obstetric ultrasound and the factors that lead to accessibility include not only awareness of where the service is available but also being in the proximity of the service provider and receiving the guidance of the provider during pregnancy check-ups. All of these help to lead to better access to maternal care. But issues of wait times, availability and pricing continue to stand in the way. Financial and operational barriers make inequalities in access and timeliness of services to occur despite a high physical access (a score of 80% or above).

The study's results suggest that portable obstetric ultrasound services deliver diagnostic and high-quality, reliable and clear imaging. This is a very important factor in making the early detection of pregnancy problems. Accurate and clear ultrasound results bring professional judgment improvements, patient trust, as well as faster referrals and treatments. The efficacy and quality of the portable ultrasound services is essential to improving maternal health in the study region, where the quality of the diagnostics is a vital part.

The findings from this study on portable obstetric ultrasonography services suggest that the cost of portable services is an important factor in the decision to use. Despite believing they

get reasonable-priced, high-quality treatment, many rural women regard the services as being beyond of their price range. The results show ultrasound increases the total cost of prenatal care and in some cases, pregnant women are financially burdened to delay or forgo prenatal ultrasound. These are points of major concern where fair access and access at all times is concerned.

The studies on portable obstetric ultrasonography have demonstrated that the services possessed a high degree of practicality, the providers were competent, the equipment use and technical performance was good and findings communication was clear and concise. When the doctor and nurse use the machine to diagnose, the patient believes that they are well trained in knowing the proper functioning of the machine. There may also need to be some work on the interpersonal aspects of the service delivery as there were some minor problems with communication with patients and explaining outcomes.

5.5 Recommendations

We adapted our ULTRA Programme for use in Malindi Sub-County to provide portable obstetric ultrasound services, and here are some of the lessons learned by the women living in the area, based on the results of the study:

i. The Kilifi County Department of Health and the management of Malindi Sub-County Hospital should also decentralize ultrasound services to lower level health facilities in order to enhance provision of this service to the communities and increase the capacity of Community Health Promoters in outreach work. This will benefit geographical access, minimise wait times and optimise the use of ultrasound services by pregnant women in timely fashion.

ii. The County Department of Health and health facility management should ensure regular maintenance and calibration of portable ultrasound equipment and continuous professional training for health care providers on the operation and interpretation of

ultrasound to improve the quality of imaging and diagnosis. This will increase the certainty of diagnosis, aid in the early detection of pregnancy complications, and help clinical decisions.

iii. The County Government of Kilifi, Ministry of Health and health financing agencies should provide funding for portable obstetric ultrasound services to help decrease cost related barriers and integrate into public funded maternal healthcare programmes. This will desensitize the financial burden of out-of-pocket expenses of low-income rural women and will enhance equitable access to diagnostic services.

iv. The health facility management should enable continuous capacity building of health care providers, both with regard to the functioning of the portable ultrasound equipment and effective patient communication, in order to increase the usability of portable obstetric ultrasound services. There should also be established regular mentorship and supportive supervision to ensure consistent, patient-centred and quality delivery of ultrasound services.

v. The Ministry of Health and County health authorities should create clear operational guidance that will facilitate the integration of portable obstetric ultrasound services into maternal health programmes in a way that strengthens policy and implementation frameworks. These guidelines should focus on affordable, accessible, quality assurance and capacity building of providers to improve maternal health outcomes in rural areas in the long-term.

5.6 Suggestions for Further Research

Based on the findings and limitations of this study, the following areas are recommended for further research:

i. Further research is needed on the comparative nature of the accessibility, use, and effectiveness of POU services in rural and urban areas and how this may affect maternal

outcomes in order to understand differences in these services across geographical locations and their impact on maternal outcomes.

ii. Further research is needed to undertake cost-effectiveness analyses and understanding the views of healthcare providers of portable obstetric ultrasound services. Research of this kind would yield evidence of the economic feasibility of scaling up the technology and the provider-related factors that impact the successful integration of the technology into the maternal health services, such as competencies and training needs, as well as operational challenges.

iii. More research is needed to employ a longitudinal study design and evaluate the long-term effects of the portable obstetric ultrasound services on maternal and neonatal health. This would give a better understanding of alterations in health outcomes as well as health seeking behavior during and after pregnancy.

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APPENDICES

Appendix I: Letter of Introduction

Peter Cynthiah Ann Njeri,
Catholic University of Eastern Africa,
Nairobi
26th April, 2025

Dear Respondent,

RE: LETTER OF INTRODUCTION FOR DATA COLLECTION

I am a master's student that is pursuing a post graduate degree focusing on Development Studies at Catholic University of Eastern Africa. The title of my research is ***"Portable Obstetric Ultrasound Services and Maternal Health Outcomes Among Rural Women in Malindi Sub-County Hospital in Kilifi County, Kenya".***

The main aim of this particular study is to gather data relating to maternal health outcomes, challenges, as well as service delivery effectiveness in Kilifi County. Your views and experiences are extremely valuable in helping improve services and inform evidence-based interventions. The information that you will provide will be treated with the highest level of confidentiality and used strictly for research purposes.

Participation in this study is purely voluntary. You have the right to decline to answer any questions as well as withdraw at any time of the exercise. The questionnaire will only take approximately 30 minutes and will be conducted in a manner that ensures your comfort and privacy.

Thank you in advance for your time as well your valuable involvement to this important study.
Yours Faithfully,
Peter Cynthiah Ann Njeri
Student ID: 1062138
Tel: +254 710.324.618
Email: cynthiahpeter64@gmail.com

Appendix II: University Research Letter

THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

Faculty of Arts and Social Sciences

Department *of Social Sciences and Development Studies*

20th January 2026

The Director
National Commission for Science, Technology and Innovation
Box 30623 - 00100
NAIROBI - KENYA

Dear Sir/Madam,

***RE: CYNTHIAH ANN NJERI* - REG. NO.: 1062138**

This letter is to confirm that the above-named individual is a final-year student pursuing a Masters of Arts Degree in Development Studies at The Catholic University of Eastern Africa.

As part of the degree requirements, she is undertaking a research study with the title:

"Portable Obstetrics Ultrasound Services and Maternal Health Outcomes among Rural Women in Malindi Sub-County Hospital, Kilifi County - Kenya"

The information gathered during this study will be used solely for academic purposes and will be handled with strict confidentiality.

Any assistance provided to her would be greatly appreciated.

Yours faithfully,

THE CATHOLIC UNIVERSITY OF EASTERN AFRICA HEAD OF DEPARTMENT 20 JAN 2026 SOCIAL SCIENCES AND DEVELOPMENT STUDIES P. O. Box 62157 - 00200, NAIROBI

Dr. Mary Mutisya
HoD, Department of Social Sciences and Development Studies

THE CATHOLIC UNIVERSITY OF EASTERN AFRICA (CUEA) P.O. BOX 62157 00200 Nairobi – KENYA
Tel: 020-2525811-5, 8890023-4, Fax: 8891084, Email: Website: www.cuea.edu
Founded in 1984 by AMECEA (Association of the Member Episcopal Conference in Eastern Africa)

Appendix III: Research Permit from NACOSTI



REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 201320

Date of Issue: 31/January/2026

RESEARCH LICENSE

This is to Certify that Ms.. CYNTHIAH ANNE NJERI PETER of Catholic University of Eastern Africa, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kilifi on the topic: PORTABLE OBSTETRIC ULTRASOUND SERVICES AND MATERNAL HEALTH OUTCOMES AMONG RURAL WOMEN IN MALINDI SUB-COUNTY HOSPITAL, KILIFI COUNTY, KENYA. for the period ending : 31/January/2027.

License No: NACOSTI/P/26/4183752

201320

Applicant Identification Number

Ag. Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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See overleaf for conditions

Appendix IV: Questionnaire for Pregnant mothers

This questionnaire is designed to collect information on the influence of portable obstetric ultrasound services on implementation of maternal and child health projects in Kilifi County, Kenya. Please respond to the questions with utmost honesty and accuracy. The data gathered from this questionnaire will be utilized for its designated purpose, ensuring that all information and replies provided will remain confidential.

Part I: Biographical Information of the Respondents

1. What is your highest level of education?
   - i.Primary level [ ]
   - ii.Secondary/ High school level [ ]
   - iii.Certificate college [ ]
   - iv.Diploma college [ ]
   - v.Bachelors' degree [ ]
   - vi.Post graduate [ ]
   - vii.Other [ ]
2. How far along are you in your pregnancy?
   - i.1st Trimester [ ]
   - ii.2nd Trimester [ ]
   - iii.3rd Trimester [ ]

Part II: Variables of the Study

Section A: Dependent Variable – Maternal Health Outcomes among Rural Women in Kilifi County

3. Part II of the research instruments presents statements based on maternal health outcomes among rural women in Kilifi County. Provide a view on the level of which you agree or disagree with the following statements from a scale of 1-5 where 5= Strongly Agree (SA), 4= Agree (A), 3= Neutral (N), 2= Disagree (D)1=Strongly Disagree (SD)

Statements	1	2	3	4	5
Expectant mothers are required to attend at least eight antenatal care visits during pregnancy.					

There are skilled health professional to assist expectant mothers during childbirth.					
Expectant mothers receive postnatal care within 72 hours after delivery.					
I consistently take iron and folic acid supplements as prescribed during pregnancy.					
I had a clear plan for delivery, including transportation and healthcare facility selection.					
I am knowledgeable about danger signs to watch for during pregnancy and childbirth.					
I was satisfied with the quality of the maternal healthcare services I received.					
There is timely access to emergency obstetric and neonatal care services when needed.					

Section B: Independent Variables – Extent of Accessibility of Portable Obstetric Ultrasound Services

4. Provide your responses on your level of agreement or disagreement from a scale of 1 – 5 regarding accessibility of portable obstetric ultrasound services where 5= Strongly Agree (SA), 4= Agree (A), 3= Neutral (N), 2= Disagree (D)1=Strongly Disagree (SD)

Statements	1	2	3	4	5
Portable obstetric ultrasound services are available within a short distance from my home.					
I know where to access portable ultrasound services during my pregnancy					
The cost of accessing portable obstetric ultrasound services is affordable for me.					
There are financial challenges involved when seeking portable ultrasound services.					
I had at least one portable ultrasound scan during my antenatal care visits.					
Healthcare providers regularly recommended the use of portable ultrasound during my pregnancy.					
I was able to access portable ultrasound services without long waiting times.					
Whenever a portable ultrasound was needed, it was readily available at the clinic					

Section C: Quality of Imaging and Diagnostics on Early Detection of high-risk pregnancies

5. Through a Likert scale of 1 – 5 regarding quality of imaging and diagnostics on early detection of high-risk pregnancies, kindly give your judgement on the level which you agree or disagree with the following statements from scale of 1-5 where 5= Strongly Agree (SA), 4= Agree (A), 3= Neutral (N), 2= Disagree (D)1=Strongly Disagree (SD)

Statements	1	2	3	4	5
The ultrasound images were clear enough for the healthcare provider to make a diagnosis.					
The quality of imaging met my expectations for identifying pregnancy complications					
The portable ultrasound accurately detected issues related to my pregnancy.					
I trust the diagnostic information provided after my ultrasound examination					
Potential pregnancy complications were detected early during my prenatal visits.					
During antenatal, health-care providers used the ultrasound results promptly to plan my care					
The healthcare provider appears confident while interpreting ultrasound results.					
The diagnosis and explanations are consistent with other medical assessments I receive.					

Section D: Cost of Portable Obstetric Ultrasound Services

6. Provide your responses on your level of agreement or disagreement using a Likert scale of 1 – 5 regarding the cost of portable obstetric ultrasound services, where 5= Strongly Agree (SA), 4= Agree (A), 3= Neutral (N), 2= Disagree (D)1=Strongly Disagree (SD)

Statements	1	2	3	4	5
The fee for portable obstetric ultrasound services was reasonable.					
The price of the portable ultrasound service matched the quality of care provided					
I could easily afford to pay for portable ultrasound services during my pregnancy.					
The cost of portable ultrasound services did not cause financial strain on my household					
I spent more on portable ultrasound services than on other antenatal services.					
Accessing portable ultrasound services significantly increased my antenatal care costs					
High costs prevented me from accessing portable ultrasound services when I needed them.					
If the portable ultrasound services were cheaper, I would have used them more frequently.					

Section E: The extent of usability of Portable Obstetric Ultrasound Services

7. Regarding usability of portable obstetric ultrasound services, give your opinion on the extent you agree or disagree with these statements where 5= Strongly Agree (SA), 4= Agree (A), 3= Neutral (N), 2= Disagree (D)1=Strongly Disagree (SD)

Statements	1	2	3	4	5
The healthcare providers operate the portable ultrasound machine efficiently.					
The ultrasound procedure is performed smoothly without technical difficulties					

The images produced by the portable ultrasound are clear and easy for the provider to interpret					
The results from the portable ultrasound scan appear accurate and trustworthy.					
The healthcare provider seemed well-trained in using the portable ultrasound equipment.					
The healthcare providers can use the portable ultrasound device correctly.					
The healthcare provider explains the ultrasound procedure clearly to patients.					
Results of the ultrasound after explained by the healthcare provider to the expectant mothers.					

Thanks for Your Cooperation

Appendix V: Interview Guide for Healthcare Providers

Introduction:

Good day. I am a master's student pursuing a postgraduate degree in Development Studies at the Catholic University of Eastern Africa. My research is titled **"Portable Obstetric Ultrasound Services and Maternal Health Outcomes Among Rural Women in Malindi Sub-County Hospital, Kilifi County, Kenya."**

The purpose of this interview is to gather information on maternal health outcomes, challenges, and the effectiveness of portable obstetric ultrasound service delivery in Malindi Sub-County. Your professional experiences and opinions are crucial for understanding how these services impact maternal health. All information you provide will be confidential and used strictly for research purposes. Participation is voluntary, and you may decline to answer any question or withdraw at any time. The interview will take approximately 30 minutes.

Interview Questions

A. Accessibility of Portable Ultrasound Services

1. How accessible are portable obstetric ultrasound services to pregnant women in Malindi Sub-County?
2. What factors influence women's ability to access these services (e.g., distance, transport, operating hours)?
3. Are there any barriers that prevent women from accessing portable ultrasound services? How can these be addressed?

B. Quality of Imaging and Diagnostics

4. How would you describe the quality of imaging and diagnostic results from the portable ultrasound devices?
5. In your experience, how has the use of these devices improved early detection of maternal or fetal complications?
6. What challenges, if any, affect the accuracy or reliability of portable ultrasound services in this facility?

C. Cost of Services

7. How affordable are the portable ultrasound services for the women attending this facility?
8. How does cost influence women's willingness or ability to utilize the services?
9. Are there any strategies in place to reduce cost-related barriers?

D. Usability of Portable Ultrasound Services

10. How easy are the portable ultrasound devices to operate for both staff and patients?
11. What training or support do healthcare providers receive to ensure proper use of these devices?
12. How does usability influence the frequency and consistency of service delivery?

E. Maternal Health Outcomes

13. In your opinion, how has the introduction of portable obstetric ultrasound services affected maternal health outcomes in the sub-county?
14. Can you share any specific examples where early detection via portable ultrasound prevented complications or improved maternal care?
15. What recommendations would you make to enhance the effectiveness of portable ultrasound services in improving maternal health outcomes?

Closing Statement:

Thank you for your time and for sharing your valuable insights. Your input will contribute significantly to understanding and improving maternal health services in Malindi Sub-County.

Appendix VI: Interview Guide for Community Health Promoters

Title: Portable Obstetric Ultrasound Services and Maternal Health Outcomes Among Rural Women in Malindi Sub-County Hospital in Kilifi County, Kenya.

Objective: To understand CHPs' perspectives on the accessibility, usability, quality, and cost of portable ultrasound devices, and their impact on maternal healthcare delivery.

Participants: 15 Community Health Promoters involved in antenatal care and maternal health services.

Duration: 60-90 minutes

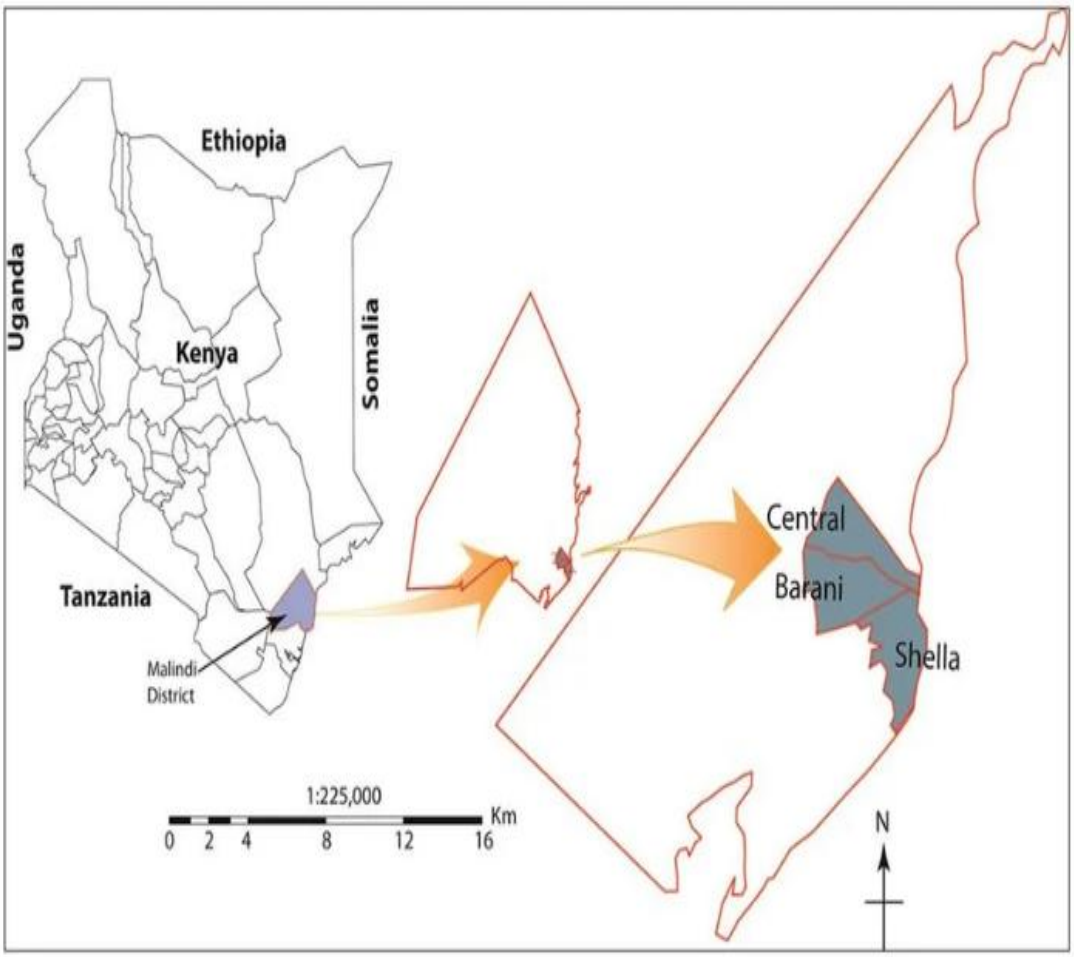
1. Can you tell us how you help pregnant women in your community?
2. Have you ever seen or heard about the small devices used to check babies in the womb (portable ultrasound)? What do you know about them?
3. Are these devices available in your health center or nearby? If yes, how often are they used?
4. In your community, is it easy or hard for women to get scanned with this device? What makes it easy or difficult?
5. Have you seen any problems when the device is used, like unclear pictures or not working well? Please share.
6. Do the health workers who use the device find it easy or hard to use? What have you seen or heard?
7. Have you or anyone you know received training or information about this device? What kind of help would be useful?
8. Do women in your community pay money to use this device? Is it affordable for most of Othem?
9. Have you seen a woman's health improve because of this device? Can you share any story where it helped?

10. What do you think can be done to help more women benefit from these devices?

11. Is there anything else you want to share about how this device is used or how it helps mothers?

Thank you for your participation

Appendix VII: Map of the Study Area



Map of Kenya showing Malindi District and urban study area of Central, Barani and Shella.

Appendix VIII: Antiplagiarism Certificate

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I HEREBY CONFIRM THAT **PETER CYNTHIAH ANN NJERI** REG NO: **1062138**, SUBMITTED A CHECK OF ANTIPLAGIARISM ON EVALUATION OF **PORTABLE OBSTETRIC ULTRASOUND SERVICES AND MATERNAL HEALTH OUTCOMES AMONG RURAL WOMEN ATTENDING MALINDI SUB-COUNTY HOSPITAL, KILIFI COUNTY, KENYA. A THESIS SUBMITTED TO THE FACULTY OF ARTS AND SOCIAL SCIENCES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR MASTER OF ARTS DEGREE IN DEVELOPMENT STUDIES OF THE CATHOLIC UNIVERSITY OF EASTERN AFRICA, KENYA.**

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Founded in 1984 by AMECEA (Association of the Member Episcopal Conferences in Eastern Africa)