OBSTETRIC FISTULA IN MALAWI: PREPAREDNESS FOR PREVENTION AND MANAGEMENT OF OBSTETRIC FISTULA

Submitted by

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Declaration

I, Dr Khumbo Jere, declare that:

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1. **Outcomes of Surgical Repair of Obstetric Fistulae at a Tertiary Referral Centre in Malawi** (published in African Journal of Obstetrics and Gynaecology)
   DOI: https://hdl.handle.net/10520/ejc-afjog_v2_n1_a4 Authors: Khumbo Jere, Salome Maswime, Amos Adelowo
2. **Geospatial Analysis of Antenatal Care Utilization and Obstetric Fistula in Malawi: Bridging Maternal Health Disparities**
   (Submitted to BMC Global and Public Health for review)
   Authors: Khumbo Jere, Salome Maswime, Amos Adelowo
3. **Geospatial Analysis of Obstetric Fistula Prevalence and Repair Services in Malawi: Evaluating Healthcare Access, Equity, and Efficiency in Maternal Health Outcomes**
   Submitted to BMC Surgery for review.
   Authors: Khumbo Jere, Salome Maswime, Amos Adelowo

For each of these publications, I was responsible for conceptualization, study design, data collection, geospatial modelling, statistical analysis, and manuscript drafting, with co-authors contributing in advisory, analytical, and editorial capacities".

Signature: Signed by candidate

Date:24 November 2025

Dedication

“This PhD thesis is dedicated to the unwavering pillars of my life—those who have shaped, nurtured, and stood by me through every challenge and triumph.

To my beloved parents, **Felix Boy Darson Jere** and **Isabel Muthoni Jere**, your sacrifices, guidance, and unconditional love have laid the foundation for the person I am today. Your unwavering belief in my potential has fuelled my determination, and your wisdom continues to light my path.

To my dear siblings, **Kahaki, Thandiwe, and Kondwani Jere**, you have been my lifelong companions, my sounding boards, and my greatest supporters. Your encouragement and faith in me have been a source of strength during the most demanding moments of this journey.

To my beautiful children, Mayamiko, **Tadala and Ozzy**, you are my greatest inspiration. Your love and innocent joy have reminded me of the importance of perseverance and purpose. Every effort I have put into this work has been with the hope of building a future where you can reach even greater heights.

And most profoundly, to my **darling wife, Phelisa Jere**, who has been my unwavering rock, my anchor in the storm, and the quiet force that has carried me through this journey. Your strength, patience, and selflessness in shouldering the responsibilities of two parents while I pursued this dream have been nothing short of extraordinary. Your sacrifices, your unwavering support, and your belief in me have made this accomplishment possible. I am endlessly grateful for your love and devotion, and I truly could not have done this without you.

This thesis is not just a culmination of my academic journey—it is a testament to the love, support, and sacrifices of those who have walked this path with me. To each of you, I dedicate this work with all my heart”.

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“I extend my deepest gratitude to the organizations, institutions, and individuals whose unwavering support and contributions were instrumental in the successful completion of this thesis.

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I acknowledge the **Division of Global Surgery**, whose unwavering support, training programs, and scholarships laid the foundation for my academic and professional growth. Through

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Finally, I am profoundly indebted to the **study participants**, whose experiences and contributions formed the foundation of this research. Without their willingness to share their stories and be part of this study, this thesis would not have been possible.

To each of you, I extend my heartfelt gratitude. This achievement is as much yours as it is mine".

Abstract

Background

Obstetric fistula continues to represent one of the starkest manifestations of maternal health inequities in Malawi, affecting an estimated **13,000–20,000 women**. Its persistence—despite being both preventable and surgically treatable—signals systemic weaknesses in maternal care across the continuum. This study interrogates Malawi's readiness to prevent and manage obstetric fistula by applying the **Three Delays Framework** through a novel, triangulated methodology integrating geospatial analysis, clinical audit, and national survey data.

Methods

A mixed-methods design was used, structured around the Three Delays. Spatial modelling (using GIS) assessed district-level accessibility to fistula repair services; DHS and MICS survey data were analysed to explore antenatal care (ANC) coverage and its relationship to fistula prevalence; and retrospective audit of **2,430 fistula repair cases** at Bwaila Fistula Centre (2010–2020) was conducted to understand service utilisation and surgical outcomes. The study did not include primary qualitative data but drew on national strategy documents and peer-reviewed evidence to interpret system-level dynamics.

Findings

Delay 1 – Barriers to Care-Seeking: Although ANC attendance has improved—from **51% (ANC4+) in 2016** to **62% by 2023**—coverage remains geographically and socioeconomically inequitable. High-burden districts such as **Mangochi, Machinga, Nsanje**, and **Chikwawa** consistently showed lower ANC coverage and higher estimated fistula prevalence. These areas were also identified as having high rates of **obstructed labour**, a precursor to fistula formation. Early marriage, adolescent pregnancy, and limited reproductive health education further undermined timely care-seeking, despite the presence of national ANC campaigns.

Delay 2 – Reaching a Health Facility: Only **43% of women of reproductive age** lived within **2 hours of a fistula repair facility**, with southern districts experiencing **travel times exceeding 4–5 hours**, especially during the rainy season. GIS modelling confirmed significant geographic disparities in access. Centralisation of repair services at **Bwaila Fistula Centre in Lilongwe** (which accounts for over **80% of national repairs**) places an overwhelming burden on one facility while leaving many districts underserved. Access challenges were compounded by poor road networks, absence of maternity waiting homes, and lack of emergency transport.

Delay 3 – Receiving Adequate Care: This study found that despite the availability of surgical repair services, systemic constraints continue to undermine access to timely and comprehensive care. Women typically presented after an average delay of **7.2 years** post-fistula onset, often with complex fistulae requiring advanced surgical expertise. Anatomical closure was achieved in **92%** of cases, and failure rates declined from **28% in 2012 to 4% by 2022**, underscoring improvements in surgical care. However, post-operative follow-up remained weak, with only **36%** of patients returning for scheduled reviews, limiting assessment of continence outcomes and long-term recovery. Facilities lacked integrated psychosocial support, contraceptive counselling, and reintegration services, affecting holistic care delivery. Of the **77 fistula-trained surgeons** since 2009, only **three remain active**, all based at Bwaila, indicating severe workforce attrition and over-centralization of care. These challenges reflect a broader failure in Delay 3—ensuring receipt of adequate and sustained care even after reaching a facility.

Innovations and Strategic Insights

The study identified scalable innovations—including the use of **Health Surveillance Assistants (HSAs)** for post-operative tracking, **Fistula Ambassadors** for community

mobilisation, and **Traditional Birth Attendants (TBAs)** to support early labour referrals. These approaches show potential to address delays at multiple levels. Community-based education programmes targeting **early marriage prevention**, **adolescent health**, and **male partner engagement** were recognised as promising preventive strategies. Projections based on ANC uptake trends suggest that **universal ANC4+ coverage** will not be achieved until **after 2050**, rendering the national goal of fistula elimination by **2030** unattainable without accelerated action.

Recommendations

To improve national preparedness, this study advocates for:

- **Decentralisation of repair services**, with dedicated centres in **Mangochi, Nsanje, and Chikwawa**
- **Strengthened workforce retention** through targeted incentives and embedded training
- **Enhanced ANC coverage** via transportation subsidies, maternity homes, and mobile clinics
- **Integrated postoperative follow-up** using mHealth tools and survivor-led support groups
- **Policy reinforcement** through renewed investment in the **National Obstetric Fistula Strategy (2023–2030)**, with active engagement from **UNFPA, Freedom from Fistula Foundation**, and government stakeholders

Limitations

Geospatial models were based on dry-season travel assumptions and did not account for informal care-seeking behaviour. The clinical audit was restricted to a single centre, limiting generalisability of outcomes. Qualitative findings were not generated first-hand but drawn from secondary reports. Nonetheless, the integrated, empirical approach provides a robust cross-sectoral view of the health system's current state of preparedness.

Conclusion

This study presents the first national-level, spatially enabled analysis of obstetric fistula in Malawi aligned to the Three Delays framework. It underscores critical weaknesses in ANC linkage, geographic access, and surgical service decentralisation. While clinical repair services exist, preparedness for timely prevention and equitable care delivery remains insufficient. Without urgent health system investments, decentralised models of care, and robust community engagement, the ambition to eliminate obstetric fistula by 2030 remains aspirational. A more realistic timeline lies **beyond 2050**, contingent on transformative system reforms.

Keywords

Obstetric fistula, antenatal care, maternal health inequities, geographic disparities, Malawi, surgical access, health systems, geospatial analysis, fistula treatment, maternal morbidity.

PhD Thesis Synopsis

Title: "*Obstetric Fistula in Malawi: Preparedness for Prevention and Management of Obstetric Fistula"*

Obstetric fistula—though a preventable maternal injury—remains a stark reminder of systemic inequities in access to safe childbirth across low-resource settings. This doctoral thesis interrogates Malawi's health system preparedness to prevent and manage obstetric fistula using an interdisciplinary lens that bridges clinical evidence, spatial science, global surgery principles, and systems thinking. Rather than reinventing existing frameworks, the study exposes structural bottlenecks and maps realistic, context-sensitive pathways for strengthening maternal care. It advances a pragmatic, data-driven response grounded in the lived experiences of women, health professionals, and health systems across East and Southern Africa.

Personal Motivation and Professional Context

My journey into obstetric fistula research is deeply rooted in a life lived across four African nations—each shaping my identity and my sense of purpose in women's health. Born in Kenya, the cradle of humankind, I grew up with a consciousness of Africa's shared heritage and interconnected destinies. Raised in Malawi, the Warm Heart of Africa, I encountered first-hand the resilience of communities burdened by fragile health systems and the realities of preventable maternal harm.

Nowhere was this more vivid than on Likoma Island, where a population of 10 000 depended on only two medical officers and a handful of nurses. Emergency obstetric referrals required crossing 70 kilometres of open lake water—sometimes in a 12-hour voyage aboard the MV *Ilala*; at other times, in urgent speedboat evacuations mobilised only when a woman's life was at risk. During one such evacuation, we nearly capsized as our speedboat began taking in water. That near-drowning incident crystallised the profound inequities faced by women in labour whose lives hinged on geography and system delays beyond their control.

On Likoma, I saw the full spectrum of maternal morbidity—postpartum haemorrhage, unrelieved obstructed labour, and advanced obstetric fistula—injuries that illuminated the deep cracks within referral pathways and emergency obstetric care. These experiences marked the beginning of my calling to strengthen systems, not only to treat injury but to prevent harm.

My clinical journey later took me to Namibia, the Land of the Brave, where I encountered a different but equally complex landscape: vast rural distances, remote clinics staffed by migrant health workers, and continued inequities in specialist access. These contrasts reinforced a singular truth—that maternal health inequity is not random but structural, shaped by the organisation of health systems.

South Africa, the Rainbow Nation, refined my skills and professional identity, training me in obstetrics, urogynaecology, pelvic floor surgery, and global surgery. Here I also witnessed the ongoing burden of childbirth injuries, including obstetric fistula, particularly in provinces with long distances to emergency obstetric care. My role as a national robotic surgery proctor strengthened my identity as a clinician-educator dedicated to high-quality, equitable surgical care and workforce development.

Across all four countries, the recurring pattern was unmistakable: **where a woman lives continues to determine whether she survives childbirth**.

This thesis—shaped by lived experience, mentorship, faith, and a commitment to women's dignity—is the natural culmination of a clinical, academic, and personal journey that positions me uniquely to interrogate obstetric fistula not only as a clinical entity, but as a diagnostic marker of system performance.

Positioning Within Obstetric Practice and Safe Delivery

This thesis is anchored in the understanding that obstetric fistula is the consequence of failed intrapartum care, most often following obstructed labour. Despite global commitments to safe delivery, the study shows how the Three Delays—delays in decision-making, reaching care, and receiving adequate care—continue to undermine maternal outcomes in Malawi.

By analysing spatial disparities in antenatal care, skilled birth attendance, and emergency obstetric capacity, this research identifies precisely where women fall through the cracks. It emphasises that ANC cannot be isolated from the broader continuum of care. Safe delivery depends on timely referral, skilled intrapartum monitoring, and the availability of surgical intervention—elements central to both fistula prevention and broader maternal health outcomes.

Contribution to Global Surgery and Systems Thinking

Through the lens of global surgery, this thesis contributes to a growing body of scholarship asserting that surgical access is foundational to health equity. Fistula repair is not an isolated service; it is a litmus test of system responsiveness.

By applying the Three Delays Model and integrating GIS-based travel-time modelling, the study exposes where surgical readiness, workforce distribution, and transport systems create patterns of inequity. The work aligns directly with the Lancet Commission on Global Surgery by:

- Mapping surgical deserts using empirically validated models
- Demonstrating maldistribution of surgical workforce
- Quantifying fistula backlog and delayed access
- Arguing for decentralised, mobile, and regionalised care models

This approach reframes obstetric fistula as a systems failure requiring coordinated, multi-level reform, consistent with global commitments to Universal Health Coverage.

Link to Urogynaecology and Pelvic Floor Surgical Expertise

As a urogynaecologist and pelvic floor surgeon, I bring a clinical depth that is rarely embedded in population-level fistula research. My work spans vaginal, abdominal, and robotic pelvic surgery, and I have trained and mentored clinicians across Southern Africa.

This thesis integrates clinical insights—on fistula repair success, persistent morbidity, reintegration gaps, and physiotherapy shortages—into a systems-level argument for comprehensive pelvic floor health services. It positions pelvic floor care as central to maternal

health, rather than peripheral, reinforcing the need for multidisciplinary approaches that extend beyond fistula repair.

Structure and Argumentative Arc of the Thesis

Part I (Chapters 1–3) establishes conceptual, epidemiologic, and methodological foundations, including the Three Delays Model, spatial epidemiology, DHS/MICS data, and retrospective clinical audits.

Part II (Chapters 4–7) presents empirical findings mapped to each delay:
• Delay 1: Subnational ANC disparities
• Delay 2: Spatial access to fistula and emergency obstetric surgery
• Delay 3: Outcomes from 2,400 fistula repairs across a decade

Part III (Chapters 8–9) synthesises insights to propose actionable, evidence-based reforms—decentralisation, surgical workforce expansion, mobile models, digital tools, and GIS-informed planning.

What Sets This Thesis Apart

• **Conceptual originality:** Recasting fistula as a diagnostic marker of systemic equity
• **Methodological innovation:** Integrated geospatial, clinical, and systems analysis rarely combined
• **Policy depth:** Recommendations drawn from empirical realities, not aspirational theory
• **Professional integration:** A dual lens of surgeon and researcher, combining clinical mastery with health-system analysis

Final Note

This thesis is not just an academic contribution—it is the culmination of a journey across four nations, shaped by lived realities, clinical encounters, and a commitment to justice in women's health. It offers insights for clinicians, policymakers, and global surgery advocates, and invites a fundamental reframing of obstetric fistula from a repairable injury to a powerful diagnostic lens revealing how health systems succeed—or fail—the women they were designed to protect.

Table of contents

Table of Contents

List of tables

List of figures

Abbreviations

ANC	Antenatal care
ANC4	Antenatal care 4 visits
ANC8	Antenatal care 8 visits
BFC	Bwaila Fistula Centre
CEmOC	Comprehensive Emergency Obstetric Care
CEmONC	Comprehensive Emergency Obstetric and Neonatal Care
CGA	Centre for Geospatial Analysis
CHAM	Christian Health Association of Malawi
DHO	District Health Office
DHS	Demographic and Health Survey
EAs	Enumeration Areas
EmOC	Emergency Obstetric Care
5x EmONC	Emergency Obstetric and Neonatal Care
EPMM	Ending Preventable Maternal Mortality
FIGO	International Federation of Obstetric Gynaecology
GIS	Geographic Information Systems
GWR	Geographically Weighted Regression
HIV	Human Immune Deficiency Syndrome
HMIS	Health Management Information Systems
HREC	Human Research Ethics Committee
HSA	Health Surveillance Assistant
HSSP	Health Sector Strategic Plan
KDE	Kernel Density Estimation
LMICs	low- and middle-income countries
MASDAP	The Malawi Spatial Data Platform
MDHS	Malawi Demographic and Health Surveys
MICS	Multiple Indicator Cluster Survey
MMR	maternal mortality ratio
MOH	Ministry of Health
NGOs	Non-Governmental Organisation
NSO	National Statistical Office
NSOAP	National Surgical, Obstetric, and Anaesthesia Plan
SDG	Sustainable Development Goal
SSA	sub-Saharan Africa
TBAs	Traditional Birth Attendants
UCT	University of Cape Town
UHC	Universal Health Coverage
UNFPA	United Nations Population Fund
UNICEF	United Nations Children Fund
WHO	World Health Organization
WRA	Women of Reproductive Age

Preface

Sets the tone for the thesis, acknowledging the broader context and contributions to women's health, surgery, and health systems research in Malawi.

- Chapter **1: Introduction, Study Rationale, and Objectives**

Provides an overview of obstetric fistula as a marker of systemic inequity, introduces the Three Delays Model, and outlines the interdisciplinary approach combining clinical and geospatial methods.

- Chapter **2: Literature Review**

Critically reviews global and regional evidence on maternal health disparities, the burden and determinants of obstetric fistula, and the applications of Geographic Information Systems (GIS) in health systems research.

- Chapter **3: Methodology**

Describes the triangulated mixed-methods design, including the use of facility-based clinical data, national DHS/MICS survey datasets, and spatial analytics. The chapter also details the rationale for using GIS, ethical approvals, and analytical strategies aligned with the Three Delays framework.

- Chapter **4: Introducing GIS for Spatial Analysis in Maternal Health**

Establishes the spatial foundation for the thesis. This chapter introduces GIS techniques used to map maternal health facility distribution and explore spatial inequities in access. It does not yet link directly to any delay but provides the enabling framework for subsequent chapters.

- Chapter **5: Delay 1 – Exploring Antenatal Care Coverage and Fistula Burden**

Uses ANC coverage as a proxy for the First Delay (decision to seek care). This chapter integrates DHS/MICS survey data with GIS overlays to explore spatial patterns of ANC utilization and district-level fistula prevalence, highlighting geographic inequities in care-seeking behaviours.

- Chapter **6: Delay 2 – Accessibility and Equity in Fistula Repair Services**

Examines the Second Delay (reaching care). GIS-based travel time modelling and spatial

equity metrics (e.g., Gini coefficients, Lorenz curves) are used to evaluate accessibility to fistula repair centres and identify underserved high-need districts.

- Chapter **7: Delay 3 – Clinical Outcomes of Fistula Repair**

Focuses on the Third Delay (receiving adequate care). Based on the published manuscript, this chapter analyses clinical data from Bwaila Fistula Centre to identify predictors of surgical outcomes and system-level factors influencing care quality.

- Chapter **8: Synthesis and Integrated Discussion**

Weaves together findings from Chapters 5–7, interpreting them in relation to the Three Delays Model and broader global maternal health strategies. Emphasis is placed on system-level readiness, decentralization, and policy alignment for sustainable fistula prevention.

- Chapter **9: Conclusion and Recommendations**

Summarizes the study's contributions and proposes evidence-based strategies to improve maternal health equity, including enhancing ANC, decentralizing fistula services, and institutionalizing GIS-informed planning.

PART I: CONTEXTUALIZING THE RESEARCH

CHAPTER 1: INTRODUCTION

1.1 Global Context of Maternal Health

Maternal health remains a global public health priority, yet stark inequalities persist between high-income and low- and middle-income countries (LMICs)[1]. The World Health Organization (WHO) estimates that sub-Saharan Africa accounts for approximately 70% of global maternal deaths annually, underscoring systemic challenges in access to quality health care[2]. For every maternal death, an estimated 20-30 women suffer from severe maternal morbidity, with obstetric fistula being one of the most devastating outcomes[3]. Despite commitments under Sustainable Development Goals (SDGs), particularly SDG 3.1, to reduce maternal mortality to fewer than 70 per 100,000 live births by 2030, resource-constrained settings continue to struggle with achieving this target [4].

The global burden of maternal mortality is disproportionately concentrated in sub-Saharan Africa. Among these countries, Malawi stands out as a microcosm of the region's maternal health challenges, marked by significant geographic, systemic, and sociocultural inequities. These factors not only hinder progress toward global targets such as SDG 3 but also highlight the need for innovative, context-specific solutions. With a maternal mortality ratio (MMR) of 381 per 100,000 live births[5]—substantially higher than the global average—Malawi ranks among the ten with the highest maternal mortality rates worldwide. While significant progress has been made in improving skilled birth attendance and antenatal care (ANC) coverage, the gains have not been equitably distributed. Rural districts, home to most Malawi's population, remain underserved, with limited access to emergency obstetric care (EmOC), shortages of trained healthcare workers, under-equipped facilities, and insufficient healthcare infrastructure resulting in poor maternal health outcomes [6,7].

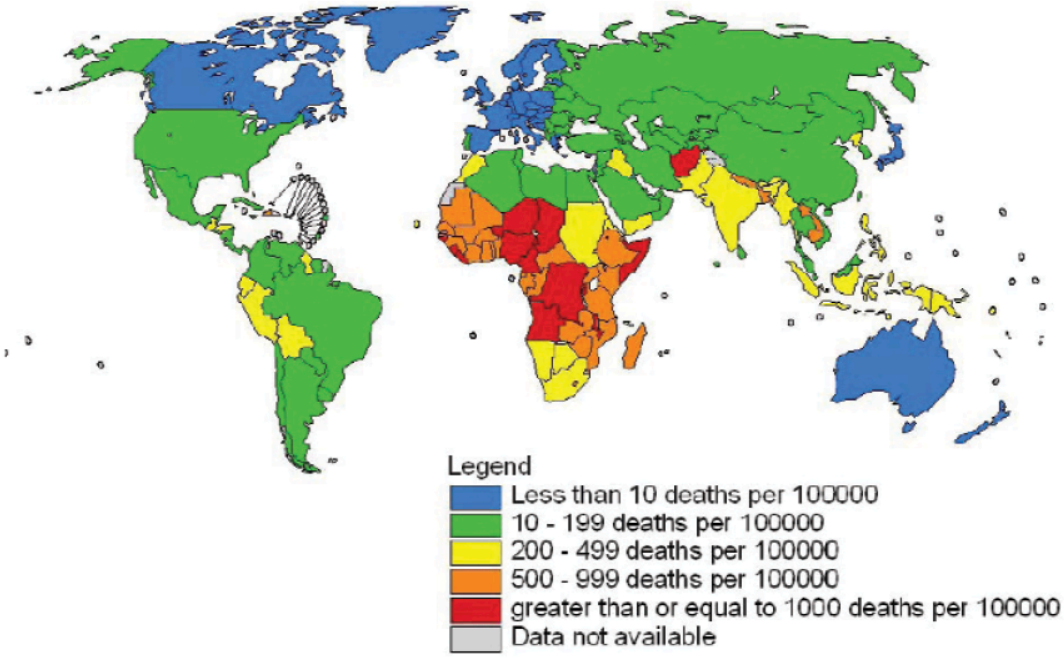
1.2 The Burden of Obstetric Fistula

Obstetric fistula serves as stark indicator of systemic failures in maternal healthcare particularly in settings with inadequate EmOC. Globally, an estimated two million women live with untreated fistula, with 50,000 to 100,000 new cases occurring annually[8] . In sub-Saharan Africa, prevalence estimates range from 1 to 3 cases per 1,000 women, with higher rates observed in rural and underserved regions[8]. Malawi's national obstetric fistula prevalence is stands at 0.6%, translating to approximately 13,000-20,000 women living with this condition.

This is further worsened by an urban-rural divide that may contribute to the high prevalence of obstetric fistula. Some rural districts report prevalence rates as high as 0.7%.

"The global distribution of obstetric fistula closely parallels patterns of maternal mortality, with the highest prevalence occurring in countries where women face the greatest lifetime risk of dying from pregnancy-related causes. This overlap underscores the shared drivers—limited access to emergency obstetric care, shortages of skilled health workers, and weak health systems—that sustain both high maternal mortality and fistula incidence."

Figure 1: **Global distribution of maternal mortality rates and their correlation with the burden of obstetric fistula**



(WHO, Used with permission)

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Countries with the highest maternal mortality ratios—predominantly in sub-Saharan Africa and parts of South Asia—overlap with regions bearing the greatest burden of obstetric fistula. This pattern reflects the shared underlying determinants, including limited access to quality intrapartum care, skilled birth attendance, and timely emergency obstetric interventions. (Source: WHO, used with permission.)

Obstetric fistula, a devastating and preventable childbirth injury, epitomizes the stark inequalities in maternal health, disproportionately affecting women in low-resource settings. It arises primarily from *obstructed labour*—a pathological state in which the foetus fails to descend despite strong and effective uterine contractions. While labour may be *prolonged yet still progressing*, it is only when prolonged, ineffective labour progresses to *true mechanical obstruction* that sustained pressure leads to ischaemic necrosis of the vesicovaginal or rectovaginal tissues, ultimately resulting in fistula formation [9,10]. According to the World Health Organization (WHO) [2], obstructed labour accounts for approximately 76% to 97% of obstetric fistula cases globally. Core contributing factors include the absence of skilled birth attendance, delayed or unavailable emergency obstetric care, lack of timely caesarean section, poor intrapartum monitoring, and failure to use partographs effectively.

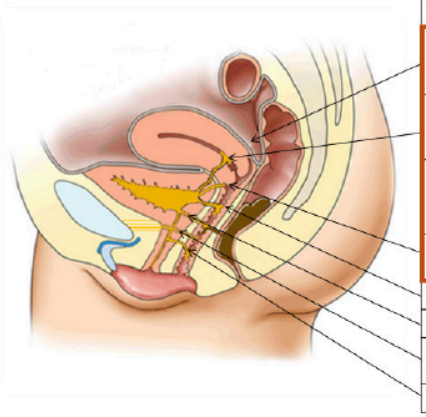
Intrapartum delays remain central to the pathophysiology of fistula. However, beyond the classical causes, there is a growing body of evidence on iatrogenic fistula. "A systematic review by ***Ngongo et al. (2022)[11b],*** covering more than 15 countries in sub-Saharan Africa, found that iatrogenic injuries—particularly those resulting from cesarean sections and hysterectomies—now account for 13% to 36% of obstetric fistula cases in some settings". These injuries are often attributed to poorly supervised surgical procedures, inadequate training, or overwhelmed health systems, especially in peripheral hospitals.

"Malawian data also reflect this pattern. In a cohort of 452 vesicovaginal fistula repairs conducted at the Bwaila Fistula Care Centre between September 2011 and July 2014, **Kopp et al. (2016)** found that 26.3% were classified as "high" fistulas—located at the vaginal apex, cervix, or uterus—and were more often associated with surgical procedures such as caesarean delivery or hysterectomy than with ischaemic necrosis from obstructed labour[11c]."

This anatomical distribution is illustrated in **Figure 1**, which maps fistula locations against Waaldijk classification and the likelihood of iatrogenic versus ischaemic origin. High fistulas—such as uretero-uterine/cervical, vesico-uterine/cervical, vault, and juxta-cervical types—are disproportionately linked to surgical injury, with some subtypes exceeding a 90% probability of iatrogenic cause (Ngongo et al., 2022). In contrast, low fistulas, such as vesico-vaginal and urethro-vaginal types, are predominantly attributable to obstructed labour.

Figure 2. **Anatomical location, Waaldijk classification, and iatrogenic likelihood of obstetric fistulas in a nine-country repair caseload.**

Fistula anatomical locations, Waaldijk classifications, and frequencies reported in a nine-country fistula repair caseload



Anatomical description	Waaldijk classification	Frequency and iatrogenic likelihood*
Uretero-uterine/cervical/vaginal *(ureter not shown)*	Type III	243 (4.1%) definitely iatrogenic
		1 (0%) not iatrogenic
Vesico-uterine/cervical	Type I	260 (4.3%) definitely iatrogenic 200 (3.3%) likely iatrogenic
Vault (after total hysterectomy) *(not pictured)*	Type I	94 (1.6%) probably iatrogenic
		15 (0.3%) not iatrogenic
Juxta-cervical	Type I	569 (9.5%) not iatrogenic
Vesico-vaginal	Type IIAa	2676 (44.6%)
Bladder neck		
Subsymphyseal/ circumferential	Type IIAb	674 (11.2%)
Urethro-vaginal	Type IIBa/IIBb	693 (11.6%)

"High" fistula

*Frequencies reported in Ngongo CJ, Raassen TJIP, Mahendeke M, Lombard L, van Roosmalen J. Iatrogenic genito-urinary fistula following caesarean birth in nine sub-Saharan African countries: a retrospective review. BMC Pregnancy Childbirth. 2022 Jul 5;22(1):541.

The denominator of 5,997 fistulas additionally includes recto-vaginal fistula (405, 6.8%), irreparable fistula (19, 0.3%), urethral incontinence (134, 2.2%), bladder stone (7, 0.1%), and vaginal stenosis (6, 0.1%).

Figure 1. Fistula anatomical locations, Waaldijk classifications, and frequencies reported in a nine-country fistula repair caseload

"Figure 2. *Anatomical location, Waaldijk classification, and proportion of iatrogenic versus ischaemic origins for obstetric fistulas, based on a nine-country caseload. High fistulas are more likely to be associated with surgical injury, while low fistulas are predominantly linked to obstructed labour. Adapted from Ngongo et al. (2022)".*

While these data underscore the significance of iatrogenic causes, national-level surveillance in Malawi remains limited. Clinical observations point to a growing number of postoperative fistula cases, particularly in district hospitals following caesarean deliveries, yet systematic audits, quality-assurance mechanisms, and comprehensive reporting are lacking. Strengthening such monitoring systems is critical to quantifying the true burden and informing targeted prevention strategies.

1.3 Strategies to Reduce Obstetric Fistula

Preventing obstetric fistula requires an integrated systems approach across the continuum of care:

- **Enhancing intrapartum care**: Ensuring consistent use of partographs, increasing availability of skilled birth attendants, and guaranteeing timely access to cesarean section are essential—especially in rural districts where the burden is greatest.

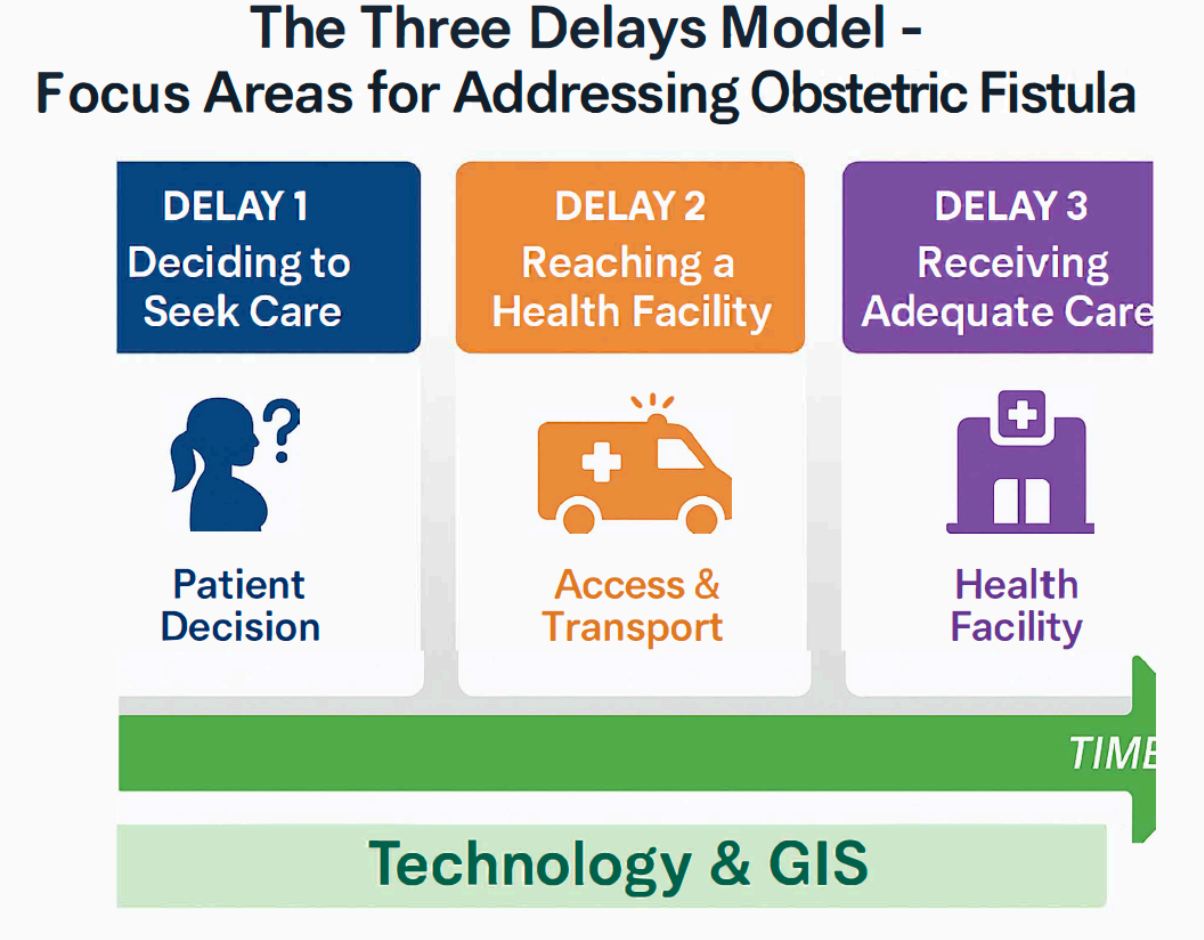
- **Improving surgical safety**: As the burden of iatrogenic fistula grows, structured training, surgical mentorship, and competency-based credentialing are critical to ensure safe operative deliveries and hysterectomies.
- **Expanding EmONC coverage**: Strengthening referral facilities with comprehensive emergency obstetric and neonatal care (CEmONC) and robust transport systems will reduce Delay 2 and improve emergency response.
- **Community-based interventions**: Empowering women and traditional birth attendants through education about labour danger signs, birth preparedness, and health facility delivery can reduce Delay 1.
- **Health system accountability**: Establishing fistula tracking systems, routine surgical audits, and quality improvement protocols can reduce iatrogenic injuries and improve case management.

Ultimately, the reduction of obstetric fistula aligns directly with the global strategy for maternal health equity and safe surgery. Closing the gaps in both timely intrapartum care and surgical quality will be critical in achieving the 2030 Sustainable Development Goals (SDGs), particularly SDG 3.1 (reducing maternal mortality) and SDG 3.8 (universal health coverage).

1.4 Framing Maternal Health through the Three Delays Model

To comprehensively understand the drivers of obstetric fistula in low-resource settings, this thesis is anchored in the ***Three Delays Model*** proposed by Thaddeus and Maine (1994). This framework categorizes the progression of preventable maternal morbidity into three critical junctures: (1) the delay in deciding to seek care, shaped by sociocultural, informational, and economic barriers; (2) the delay in reaching an appropriate healthcare facility, often driven by geographic and infrastructural limitations; and (3) the delay in receiving adequate care upon arrival, linked to facility readiness, workforce availability, and quality of clinical management. This model offers a robust conceptual lens to evaluate the preparedness of health systems to prevent and manage obstetric fistula. The structure of this thesis mirrors this progression—each chapter interrogates one delay through a distinct yet interconnected methodological approach, including sociocultural analysis (Delay 1), spatial access modelling (Delay 2), and surgical audit of fistula care (Delay 3).

Figure 3: Advanced Thematic Adaptation of the Three Delays Model for Obstetric Fistula Research in Malawi.



This adapted framework builds on the original Thaddeus and Maine (1994) Three Delays Model, integrating geospatial analytics, clinical audit data, and population-based survey metrics to capture the multifactorial pathways to obstetric fistula. It contextualises Delay 1 (decision to seek care), Delay 2 (reaching care), and Delay 3 (receiving adequate care) within Malawi's maternal health system, linking socio-cultural, infrastructural, and health system determinants to both preventive and adverse outcomes. The model incorporates technology-driven components such as GIS-based travel time modelling, service coverage mapping, and facility readiness audits, offering a robust, data-driven lens for identifying intervention points and informing evidence-based policy.

Applying the Model to the Malawian Context

While global and regional analyses offer valuable insights into the structural determinants of obstetric fistula, translating these lessons into targeted interventions necessitates localized evidence. Malawi presents a compelling case study of how all three delays intersect to exacerbate the burden of maternal morbidity. Here, entrenched sociocultural norms—such as early marriage and gendered health decision-making—interact with systemic gaps in

geographic access, referral systems, and facility preparedness to produce adverse maternal outcomes. Understanding the nuanced manifestation of these delays in the Malawian context is critical for designing interventions that are both feasible and effective. This study leverages the Three Delays Model as a guiding framework to evaluate the health system's capacity across the continuum of maternal care, ultimately informing policy, programming, and future research on obstetric fistula prevention and response.

Delay 1: Sociocultural and Informational Barriers to Timely Care-Seeking

In Malawi, systemic barriers—including suboptimal antenatal care (ANC) utilization, weak referral systems, and inadequate healthcare infrastructure—exacerbate the risk of complex deliveries. These challenges often culminate in delayed arrival at health facilities with obstructed labour, significantly heightening the risk of obstetric fistula [11]. According to the Thaddeus and Maine Three Delays framework, these issues typify the **first delay**: the delay in deciding to seek care. This delay is often driven by deeply rooted sociocultural and informational barriers that prevent women from recognizing the severity of labour complications or acting upon them in time.

Contributing factors such as early marriage, adolescent pregnancy, restricted autonomy in health-related decision-making, low maternal health literacy, and stigma associated with childbirth complications collectively impede timely care-seeking [12,13]. In rural districts especially, these factors reduce the likelihood of delivering in a facility and limit opportunities for early risk identification during pregnancy. Consequently, many women present late for emergency obstetric care, often after obstructed labour has already caused irreversible damage, including vesicovaginal or rectovaginal fistula.

The consequences of obstetric fistula extend well beyond physical morbidity. Affected women often endure chronic incontinence, recurrent infections, secondary infertility, and profound social consequences—such as ostracism, marital breakdown, and economic exclusion [9,10]. These cascading effects underscore the need for comprehensive, community-informed strategies to address the determinants of Delay 1.

However, even when the decision to seek care is made in time, significant challenges often arise in the second phase: reaching appropriate care. Geographic and infrastructural barriers—such as long distances to health facilities, poor road conditions, and limited transport options—

compound maternal risk [14]. The following section explores Delay 2 and introduces the role of Geographic Information Systems (GIS) in mapping and addressing spatial inequities in maternal health access.

Delay 2: Barriers to Reaching Care – The Role of Geography, Transport, and Health System Access

Geographic inequities play a pivotal role in shaping maternal health outcomes in Malawi, particularly through **Delay 2** of the Three Delays Model—**the delay in reaching healthcare facilities**. In many rural and remote regions, pregnant women face immense challenges in physically accessing care due to poor road networks, seasonal flooding, and the absence of nearby healthcare infrastructure [15]. These logistical barriers, compounded by inadequate emergency transport systems, contribute directly to delayed arrival at facilities—frequently resulting in complications such as obstructed labour and obstetric fistula.

While systemic reforms such as decentralizing emergency obstetric care are essential, there is an urgent need for **innovative analytic tools** to visualize and address these geographic barriers. **Geographic Information Systems (GIS)** offer a transformative framework to bridge this gap. "GIS enables the spatial mapping of healthcare access, modelling travel times, terrain effects, and facility proximity". By layering geospatial data with clinical outcomes and population-level metrics, GIS enhances the capacity to detect inequities, identify healthcare deserts, and guide equitable resource allocation [16–21].

In this study, GIS is employed to assess spatial accessibility of antenatal care (ANC) services and fistula repair facilities, estimate travel burdens across districts, and pinpoint regions where women are most vulnerable to Delay 2. The approach provides a data-driven platform for targeted intervention—moving from reactive to anticipatory health system planning. Rather than replacing traditional planning methods, GIS complements them by offering **high-resolution, location-sensitive insights** crucial for achieving equity in maternal healthcare delivery.

Delay 3: Inadequate Care Upon Arrival—Health System Readiness and Quality Gaps

While overcoming sociocultural barriers and reaching a facility are critical steps, the **third delay**—the delay in receiving timely and adequate care upon arrival—remains a persistent and often under-addressed contributor to adverse maternal outcomes in Malawi. For women in

labour, arrival at a health facility does not guarantee access to quality intrapartum care. Many district and rural hospitals lack adequately trained personnel, essential surgical supplies, consistent electricity, and functioning operating theatres. This severely constrains their ability to deliver life-saving interventions, such as cesarean sections or assisted vaginal deliveries, at the time they are most needed.

In the context of obstetric fistula, this delay is particularly consequential. Even when women arrive at facilities in time, mismanaged obstructed labour, delays in clinical decision-making, and prolonged trial of labour in under-resourced environments can lead to tissue necrosis and fistula formation. Moreover, the rising burden of **iatrogenic fistulas**, often resulting from surgical trauma during cesarean deliveries or hysterectomies performed by inadequately trained providers, highlights systemic deficits in surgical safety and supervision. In 2022 *Ngongo et al*. highlighted that iatrogenic fistulas account for 13% to 36% of cases—underscoring an urgent need for quality assurance and surgical mentorship within expanding maternal health programs.

In Malawi, national data on iatrogenic fistulas are limited, but clinical observations and facility-level audits suggest an upward trend, particularly in lower-level facilities where task-shifting occurs without adequate oversight. This underscores the need for integrated health system strengthening efforts focused not only on expanding access but also on improving the **quality and safety** of maternal care once women are within the health system.

Together, the three delays—sociocultural decision-making, geographic access, and health system readiness—constitute a continuum of barriers that perpetuate obstetric fistula and maternal morbidity. The remainder of this thesis seeks to examine each delay through both clinical and geospatial lenses, offering evidence-based recommendations for systemic preparedness and equitable maternal care in Malawi.

1.5 Significance of the Study

This study addresses a critical gap in maternal health systems by integrating clinical audit data with geospatial analysis to examine systemic barriers to obstetric fistula prevention and care in Malawi. While many studies have explored maternal health inequalities, few have taken a multidisciplinary approach that synthesizes clinical outcomes with Geographic Information Systems (GIS) to uncover spatial inequities in care access, referral delays, and surgical

readiness. By embedding this research within the Three Delays framework, the study presents a comprehensive examination of care-seeking behaviour (Delay 1), geographic accessibility (Delay 2), and facility-level treatment capacity (Delay 3).

The significance of this work is amplified by Malawi's ongoing maternal health challenges. Despite improvements, antenatal care coverage remains suboptimal. Between 2015 and 2024, the proportion of women attending at least four ANC visits (ANC4+) increased from 51% to 62% [27] —yet still falls short of the WHO's 2016 recommendation for a minimum of eight contacts (ANC8+) to ensure quality maternal care [28] . Nearly 38% of women still do not meet even the ANC4+ threshold, particularly in underserved rural areas where barriers to care are multidimensional—financial, geographic, and sociocultural.

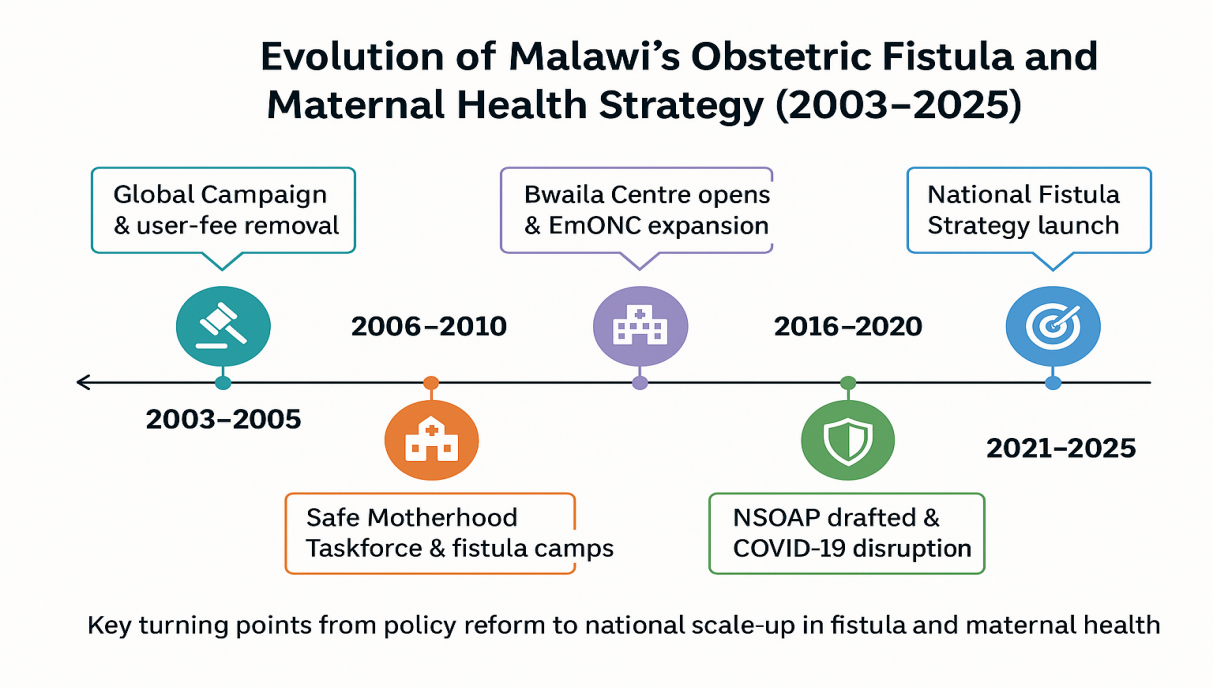
This underutilization of ANC services is closely linked to increased obstetric risk, including delayed facility arrival, and missed opportunities for birth preparedness. While ANC alone cannot prevent obstructed labour, it serves as a critical platform for risk stratification, education, and early referral—ultimately reducing the likelihood of obstructed and complicated labour that may result in obstetric fistula. Strengthening ANC coverage, especially in high-risk regions, can indirectly contribute to fistula prevention by improving timely access to skilled birth attendance and emergency obstetric care.

Importantly, while surgical repair remains vital for affected women, the sustainable elimination of obstetric fistula requires a shift toward primary prevention. This includes scaling ANC coverage, improving the referral network, and decentralizing surgical care. By aligning its findings with global goals—such as SDG 3.1, WHO recommendations, and Malawi's Health Sector Strategic Plan III (2023–2030) [40] —this research provides evidence-based pathways for strengthening the maternal health system. It offers practical tools for identifying underserved populations, prioritizing resources, and implementing strategic interventions to reduce fistula burden and enhance equity in maternal care delivery.

This study complements and builds upon two decades of evolving national strategies aimed at addressing obstetric fistula and broader maternal health challenges in Malawi. As shown in **Figure 3**, Malawi's response has progressed from policy-level reforms—such as the removal of user fees and the launch of Safe Motherhood initiatives—to more structured interventions, including the establishment of the Bwaila Fistula Centre, expansion of Emergency Obstetric and Neonatal Care (EmONC), and most recently, the launch of the National Fistula Strategy

(2023–2030). While these milestones have laid a foundation for care, persistent gaps remain in equitable access, quality of ANC, and timely surgical repair. By integrating clinical outcomes with spatial analyses, this research aligns with—and strengthens—the strategic direction of the Ministry of Health by offering data-driven insights to support scale-up, improve referral pathways, and enhance service delivery in high-burden and underserved districts.

Figure 4.Evolution of Malawi's Obstetric Fistula/ Maternal Health Strategy (2003–2025).



Research Gap

Regardless of increasing global attention to maternal health inequalities, the spatial dimensions of obstetric fistula care remain underexplored. Most studies focus on maternal mortality, yet few have systematically analysed how geographic accessibility interacts with clinical outcomes to shape maternal health disparities. While GIS has been applied in infectious disease mapping and urban health planning, its application to maternal health, particularly obstetric fistula care, remains limited [16,29–31]. Research in Tanzania and Uganda[32,33] has highlighted regional disparities in emergency obstetric care access**,** while studies in Kenya and Ethiopia have demonstrated inequitable maternal health service distribution[34–38]. However, these studies predominantly focus on mortality rather than maternal morbidity, failing to capture the spatial barriers that perpetuate obstetric fistula prevalence. This research fills that critical gap by combining GIS and clinical analyses to assess both prevention (ANC services) and treatment (fistula repair services**)**, offering a comprehensive evaluation of healthcare readiness in Malawi

Building on this critical gap, it becomes imperative to examine how antenatal care interfaces with intrapartum and surgical services in the prevention and management of obstetric fistula. While ANC coverage is a frequently promoted maternal health indicator, its true preventive value lies in timely referral pathways to skilled birth attendance and emergency obstetric care. ANC cannot operate in isolation—it must be understood as a gateway within a broader continuum of care that spans from early health-seeking behaviours to timely access and quality intrapartum management. This continuum is best captured through the lens of the Three Delays Model. The subsequent section outlines the specific study objectives developed to interrogate each delay— (1) the decision to seek care, (2) the ability to reach care, and (3) the quality of care received—thereby offering a comprehensive assessment of systemic readiness to prevent and manage obstetric fistula in Malawi.

1.6 Research Objectives

Study Objectives

The study adopts an interdisciplinary approach, integrating geospatial and clinical analyses to comprehensively assess the determinants of obstetric fistula in Malawi. By combining spatial techniques with clinical data, the study pursues the following key objectives:

1. Analyse the Spatial Distribution of Antenatal Care (ANC) Services (Delay 1 – Decision to Seek Care)

- Map ANC service coverage and geographic distribution across Malawi.
- Identify systemic and geographic barriers to ANC utilization, particularly in rural and underserved areas.
- Examine the relationship between ANC attendance and maternal health outcomes, including fistula prevalence.

2. Evaluate Accessibility and Equity in Fistula Repair Services *(*Delay 2 – Reaching Care)

- Use GIS to assess the spatial distribution and centralization of fistula repair services.
- Evaluate equity in access, focusing on rural–urban disparities and travel time burdens.
- Identify high-need areas with limited surgical service availability to inform decentralized planning.

3. Evaluate Clinical Outcomes of Fistula Repair (Delay 3 – Receiving Quality Care)

- Analyse surgical success rates, continence outcomes, and complication rates.
- Identify clinical predictors of repair success (e.g., fistula size, fibrosis, delay duration).
- Assess the impact of referral systems and provider expertise on surgical outcomes.

4. Examine the Integration of Clinical and Geospatial Determinants (Cross-cutting Objective)

- Investigate how geographic barriers (e.g., travel times, facility density) compound clinical vulnerabilities.
- Explore how ANC attendance, skilled birth attendance, and access to emergency obstetric care interact with geographic disadvantage.
- Highlight regions with both poor ANC access and high fistula prevalence to inform targeted interventions.

5. Provide Actionable Recommendations to Improve Maternal Health Equity

- Propose strategies to improve ANC coverage and quality in high-burden areas.
- Recommend decentralization of fistula repair services to enhance geographic accessibility.
- Advocate for community-based education and early care-seeking interventions.
- Emphasize the utility of spatial analytics for equitable health planning and resource allocation.

By addressing the objectives, this research provides a comprehensive evaluation of Malawi's preparedness to manage obstetric fistula. It highlights the interconnected clinical, geographic, and systemic determinants that perpetuate disparities, offering a robust framework for improving maternal health outcomes in resource-constrained settings.

Conclusion

By leveraging geospatial data and clinical insights, this study provides an evidence-based framework for optimizing maternal healthcare delivery in resource-limited settings. The findings will directly contribute to policy strategies for decentralizing fistula repair services, strengthening ANC coverage, and improving emergency obstetric care equity. Moreover, this

research informs Malawi's Health Sector Strategic Plan III (2023–2030) and global maternal health initiatives, particularly SDG 3.1 and the UNFPA's strategy to end obstetric fistula. By integrating spatial and clinical determinants, this study pioneers an innovative, data-driven approach to maternal health equity, offering scalable solutions for similar low-resource settings globally.

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CHAPTER 2 LITERATURE REVIEW

2.1 Maternal Health: Global Context and Burden

Maternal health reflects the overall health system's ability to provide equitable, quality care. Despite remarkable progress, maternal mortality remains a pressing challenge globally, with a staggering 94% of maternal deaths occurring in low- and middle-income countries (LMICs). Sub-Saharan Africa, with its fragile health systems, accounts for 66% of the deaths, emphasizing the significant disparities in healthcare access and quality. According to the World Health Organization (WHO), approximately 295,000 women died due to complications related to pregnancy and childbirth in 2017. Beyond mortality, maternal morbidities, such as obstetric fistula, severely compromise the quality of life for millions of women annually.

The 2030 Agenda for Sustainable Development set ambitious targets for global health, including the goal of reducing maternal mortality to fewer than 70 deaths per 100,000 live births under Sustainable Development Goal (SDG) 3. However, progress toward this target is significantly off track. Despite notable advancements, such as a 38% reduction in the maternal mortality ratio from 2000 to 2017, the annual decline of 2.9% is less than half the 6.4% needed to achieve the target. The global maternal mortality rate still stood at 211 deaths per 100,000 live births in 2017, with 86% of the deaths occurring in sub-Saharan Africa and Southern Asia. This persistent inequity underscores systemic health disparities in low- and middle-income countries (LMICs), where access to skilled birth attendants, emergency obstetric care, and antenatal services remains inadequate.

Global health systems, already strained by inequities and resource limitations, face further challenges due to the COVID-19 pandemic. Disruptions in essential health services, including maternal and child healthcare, have reversed years of progress. Projections indicate significant increases in maternal deaths and adverse health outcomes if the disruptions persist. For example, a 25% reduction in healthcare services over three months could lead to a 13% rise in deaths related to maternal complications in affected countries[1]. Such setbacks jeopardize the gains made in reducing maternal mortality and highlight the urgency of strengthening healthcare systems, particularly in LMICs.

In the broader context of global surgery, the gaps in access to essential surgical interventions, such as cesarean sections, exacerbate maternal health disparities. Obstetric fistula, a

preventable and treatable condition resulting from obstructed labour, remains a stark indicator of the inequities. Addressing maternal health within the framework of global surgery necessitates integrating universal health coverage (UHC) with strategies that prioritize equitable access to surgical care. Achieving UHC by 2030, however, remains a daunting challenge, with only 39-63% of the global population expected to be covered at current rates[1]. Moreover, rising out-of-pocket health expenses and insufficient health workforce capacities continue to undermine progress, disproportionately affecting women in LMICs.

This study contextualizes the maternal health crisis within the challenges of global health and surgery, emphasizing the need for data-driven, equity-focused interventions. Geographic Information Systems and spatial analyses offer critical tools for identifying underserved regions and guiding resource allocation. However, achieving the SDG 3 targets will require concerted efforts to address systemic barriers, enhance public health infrastructure, and ensure that no woman is left behind in the pursuit of health equity. The findings underscore the imperative for innovative strategies and collaborative global action to close the gaps in maternal health and fulfil the promise of sustainable development.

2.2 Obstetric Fistula: A Marker of Systemic Failures

Obstetric fistula is a debilitating childbirth injury arising from obstructed labour without timely medical intervention, such as a cesarean section[2]. Sustained pressure of the fetal head on maternal pelvic tissues causes ischemia, tissue necrosis, and eventual formation of abnormal connections, most commonly between the vagina and bladder (vesicovaginal fistula) or rectum (rectovaginal fistula). This mechanism highlights the critical importance of timely emergency obstetric care in preventing such injuries.

Obstetric fistula disproportionately affects women in LMICs, particularly those in rural and resource-constrained settings[3]. Factors such as early marriage, malnutrition, stunted pelvic growth, and poor access to skilled birth attendants amplify the risk of obstructed labour and subsequent fistula formation.

Globally, an estimated two million women live with untreated obstetric fistula, with 50,000 to 100,000 new cases reported annually.[4] In sub-Saharan Africa, prevalence estimates range from one to three cases per 1,000 women, with higher rates in rural regions. In Malawi, the

prevalence is estimated at 0.6%[5], translating to over 13,000 women living with fistula, predominantly in areas with limited healthcare access.

Historically, the epidemiology of obstetric fistula in sub-Saharan Africa has been dominated by cases arising from obstructed labour, particularly in rural settings with poor access to emergency obstetric care." However, recent literature has drawn attention to an increasing burden of iatrogenic fistulas—injuries sustained during pelvic surgery, most often caesarean sections and hysterectomies (Ngongo et al., 2022)". These injuries typically result from inadvertent bladder or ureteric trauma, compounded by limited intraoperative recognition and inadequate postoperative monitoring. The rise in iatrogenic fistulas is linked to expanded surgical access without commensurate investment in skills training, mentorship, and surgical safety systems. While Malawi-specific estimates are scarce, anecdotal reports from referral centres suggest that these cases are being encountered with greater frequency, mirroring trends across the region.

The consequences of obstetric fistula extend beyond physical morbidity. Women face chronic incontinence, recurrent infections, and secondary infertility. Socially, they experience ostracism, loss of dignity, and marital breakdown. Economically, fistula restricts their ability to participate in the workforce, further entrenching poverty. The consequences underscore the need for integrated prevention, treatment, and rehabilitation programs.

2.3 Antenatal Care (ANC): A Cornerstone of Maternal Health

Antenatal care (ANC) is a critical intervention for improving maternal and neonatal health. It provides an opportunity for early risk identification, health education, and timely management of pregnancy-related complications. The World Health Organization (WHO) recommends eight ANC visits to optimize maternal and perinatal outcomes. Regular ANC attendance reduces the likelihood of adverse events, including obstetric fistula, by facilitating early detection of complications such as cephalopelvic disproportion and hypertensive disorders.

2.3.2 Utilization and Disparities in Malawi

In Malawi, while 97% of pregnant women attend at least one ANC visit, only 51% complete four or more visits (ANC4+)[5,6]. Early initiation of ANC, a critical factor in risk management, remains low, with less than 15% of women attending their first ANC visit in the first trimester.

Disparities are particularly pronounced in rural districts, where women face geographic and financial barriers to accessing ANC services.

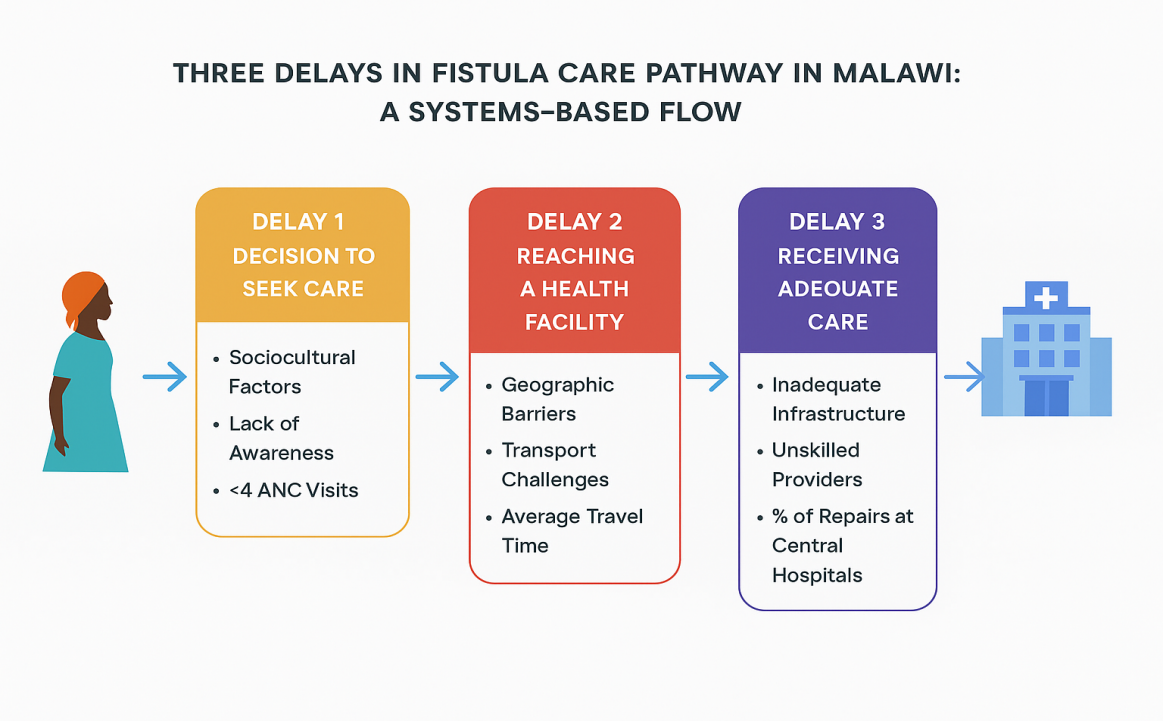
The quality of ANC also varies significantly. While most facilities offer basic services such as weight monitoring and blood pressure checks, advanced diagnostics and interventions are often unavailable, limiting the effectiveness of ANC in managing high-risk pregnancies.

2.4 Barriers to Maternal Healthcare Access

The Three Delays Model

The "Three Delays Model," introduced by Thaddeus and Maine in 1994 [7], provides a critical framework for understanding the multifaceted barriers contributing to maternal health outcomes. The model divides the barriers into three distinct but interconnected phases: delays in deciding to seek care, delays in reaching a healthcare facility, and delays in receiving adequate care once at the facility. Addressing the delays is essential for improving maternal health outcomes and reducing preventable morbidities, such as obstetric fistula. This conceptual flow diagram(figure4) below illustrates the application of the Three Delays Model in the context of obstetric fistula care. Delay 1 refers to sociocultural and informational barriers that hinder timely decision-making to seek care, including low awareness and insufficient ANC attendance. Delay 2 highlights the physical and geographic obstacles to reaching health facilities, such as transport challenges and prolonged travel times. Delay 3 captures health system-level inadequacies, including poor infrastructure, provider shortages, and centralised surgical care. Together, these delays represent critical bottlenecks in achieving equitable, timely, and high-quality fistula prevention and treatment in Malawi.

Figure 5: ***Three Delays in Fistula Care Pathway in Malawi – A Systems-Based Framework***



Phase 1: Delay in Deciding to Seek Care

The first delay arises when individuals, families, or communities fail to recognize the need for professional medical intervention or delay making the decision to seek care. This delay is influenced by:

- **Lack of Awareness**: In many rural and underserved areas of Malawi, knowledge about maternal complications and the importance of skilled care is limited. Women and their families often fail to recognize the severity of labour-related complications such as obstructed labour.
- **Sociocultural Factors**: Deeply rooted cultural norms often discourage women from seeking facility-based deliveries. For instance, reliance on traditional birth attendants (TBAs) may be preferred due to trust and cultural alignment, even when the risks are substantial.
- **Economic Constraints**: For low-income families, the perceived costs of healthcare, including transportation, medical fees, and loss of income, may delay care-seeking behaviour[8].

- **Gender Inequities**: In patriarchal societies, decision-making authority regarding health often rests with male family members. This dependence can lead to significant delays, particularly if the male figure is unavailable or unconvinced of the necessity of seeking care.

Phase 2: Delay in Reaching a Healthcare Facility

Once the decision to seek care has been made, logistical challenges often hinder timely access to healthcare facilities. This phase is particularly critical in rural Malawi:

- **Geographic Distance**: Many women in rural areas live more than 10 kilometres from the nearest healthcare facility. The physical distance alone poses a significant challenge, especially during emergencies.
- **Transportation Barriers**: Poor road infrastructure and limited transportation options compound the challenge. Ambulances are often unavailable, and reliance on bicycles, ox carts, or walking can significantly increase travel time.
- **Environmental and Climatic Factors**: Adverse weather conditions, such as heavy rains, can render roads impassable, particularly in flood-prone regions like Chikwawa and Nsanje[6].

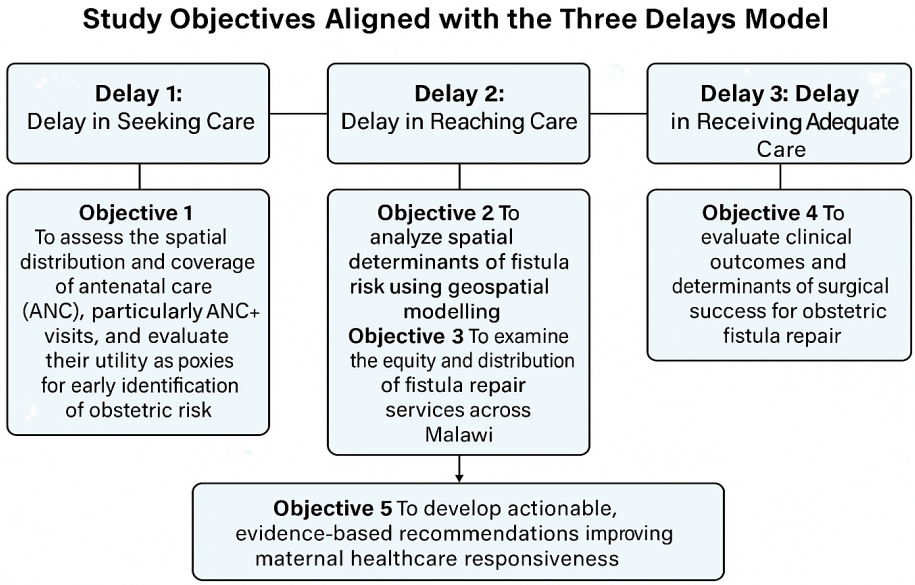
Phase 3: Delay in Receiving Adequate Care

Even after reaching a healthcare facility, systemic issues may prevent women from receiving timely and appropriate care. Contributing factors include:

- **Healthcare Infrastructure**: Many facilities in Malawi are poorly equipped, with insufficient beds, surgical instruments, or medications. This lack of infrastructure can result in life-threatening delays.
- **Human Resource Shortages**: Skilled healthcare workers, such as midwives, obstetricians, and anaesthetists, are often concentrated in urban centres, leaving rural areas underserved. The lack of trained personnel to manage complications like obstructed labour exacerbates delays.
- **Facility Overcrowding**: High patient volumes in district hospitals and referral centres can lead to long wait times, delaying critical interventions such as cesarean sections.

- **Administrative Barriers**: Delays in admission, referral processes, or access to operating theatres can further contribute to maternal complications.

Figure 6 ***Alignment of Study Objectives with the Three Delays Model***



This figure 5 above illustrates how each of the study's core objectives corresponds to one or more components of the Three Delays Model, which served as the guiding conceptual framework for this research. Delay 1 (seeking care) is addressed through the analysis of antenatal care coverage and its potential as an early risk indicator (Objective 1). Delay 2 (reaching care) is examined via geospatial modelling of fistula risk and the spatial distribution of repair services (Objectives 2 and 3). Delay 3 (receiving adequate care) is evaluated through clinical outcomes and surgical success rates for obstetric fistula repair (Objective 4). The final objective (Objective 5) integrates insights across delays to inform evidence-based recommendations aimed at strengthening maternal healthcare responsiveness and equity in Malawi.

2.5 Health Geography in Maternal Health

Health geography bridges the relationship between place and health, emphasizing how physical, social, and political environments shape human health outcomes[9–12]. By studying spatial patterns of disease, accessibility of healthcare services, and the impact of social determinants, health geographers reveal inequities that affect population health. This field integrates methodologies such as GIS mapping, spatial analysis, and mixed-methods research to uncover connections between location-specific determinants and health disparities, as demonstrated in studies ranging from infectious diseases to chronic conditions and marginalized populations.

In this research, health geography was pivotal in understanding maternal health disparities in Malawi. Using spatial analysis, the study mapped the distribution of health facilities, analysed accessibility, and assessed how geographic and social inequities influence obstetric fistula outcomes. By combining clinical data with geospatial insights, the research provides a comprehensive framework for addressing systemic inequities in healthcare access, particularly for underserved populations. In this thesis, clinical interventions refer to emergency obstetric care (EmOC) services, including timely cesarean sections, assisted vaginal delivery, and fistula repair. This integration of health geography enriches public health policy and practice, contributing innovative tools for equitable healthcare planning.

"Geographic Information Systems (GIS) is a transformative analytical tool that integrates spatial and non-spatial data to visualize, analyse, and interpret complex relationships across geographic spaces[13]. In addressing public health challenges, including maternal health inequities, this enables the integration of diverse data types into spatial layers, such as healthcare facility locations, road networks, population distributions, and maternal health outcomes[9,11]. This layered approach allows for in-depth analyses of interrelationships between geography and health[14,15]. Through geocoding, GIS transforms descriptive location data into precise geographic coordinates, facilitating accurate mapping of healthcare facilities and population centres while highlighting disparities in healthcare access[16,17]. Advanced spatial analysis techniques, including proximity analysis, hotspot detection, and network analysis, uncover critical insights by calculating distances to healthcare facilities, identifying clusters of maternal health challenges, and assessing transportation and connectivity[11]. Moreover, GIS generates intuitive visual outputs that effectively communicate complex datasets, empowering

policymakers, and stakeholders to design targeted interventions, advocate for resource allocation, and optimize healthcare delivery systems.

2.5.2 Applications of GIS in Maternal Health

GIS has been increasingly adopted as a decision-support tool to map maternal health disparities, especially where access to timely care determines outcomes. It allows for spatial modelling of health facility coverage, travel time, and service catchment to assess inequities in maternal care. In Ethiopia, GIS analyses have identified significant regional disparities in maternal health service utilization, with rural areas exhibiting lower antenatal care coverage and higher maternal mortality rates compared to urban centres[12].Similarly, in Uganda, spatial analyses have revealed that women in rural regions face substantial challenges in accessing maternal health services, contributing to higher rates of obstetric complications.[18,19]In Kenya, GIS has been utilized to map the distribution of maternal health services, uncovering inequities that affect healthcare utilizatio[20,21] .Tanzania has employed geospatial analyses to identify gaps in the availability and accessibility of maternal health facilities, highlighting areas that require targeted interventions to improve maternal health outcomes[22] .Rwanda's application of GIS has focused on optimizing the distribution of healthcare facilities to enhance accessibility for maternal health services[9]. In Malawi, GIS studies have been conducted to assess the geographical accessibility of maternal health services, identifying regions with limited access that correlate with higher maternal mortality rates[22]. Mozambique has utilized GIS to evaluate the impact of geographical barriers on maternal health service utilization, emphasizing the need for improved infrastructure to enhance access to care[18].

Future studies should prioritize leveraging advancements in GIS technology, such as AI integration, machine learning, and geospatial big data analytics, to improve the global tracking of obstetric fistula burden and maternal health outcomes. By enhancing the precision of spatial and temporal analyses, researchers can identify high-risk regions, optimize resource distribution, and predict trends more effectively[23]. Real-time data collection through wearable devices and mobile health platforms can provide continuous insights into healthcare access and maternal health behaviours, particularly in underserved populations. Participatory GIS approaches should also be emphasized, engaging communities to contribute localized data and fostering ownership of health interventions. Standardizing GIS methodologies and fostering global collaboration are essential for creating unified datasets, enabling cross-border research, and ensuring that findings inform coordinated global strategies[24]. The innovations will not only

refine our understanding of fistula prevalence and determinants but also empower data-driven policy-making to achieve equitable maternal health outcomes worldwide.[23,25] **"**The spatial modelling in this study is grounded within the Three Delays Framework, aligning delay typologies with physical accessibility and service availability metrics."

2.6 Conclusion

Studies highlight the complex interplay of geographic, clinical, and sociocultural factors shaping maternal health outcomes. Addressing obstetric fistula requires a multifaceted approach that integrates geospatial analyses with targeted clinical interventions. By understanding the determinants of maternal health disparities, this study seeks to provide actionable evidence for improving healthcare access and equity in Malawi. While GIS does not offer direct clinical solutions, it provides policymakers with evidence to better allocate resources and prioritize underserved areas. This thesis builds on previous studies by integrating spatial modelling with national survey and clinical audit data to holistically examine maternal health readiness.

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CHAPTER 3: METHODOLOGY

3.1 Mixed-Methods Approach: Rationale and Relevance

Introduction

This research was conducted in Malawi, a low-income, landlocked country in south-eastern Africa, bordered by Mozambique, Zambia, and Tanzania. Malawi is one of the poorest nations globally, with nearly 70% of its population living on less than $2.15 per day[1]. The country's population, estimated at 21 million in 2023, is growing at an annual rate of 2.6%. Half of the population comprises children, reflecting significant demographic pressures on essential services, particularly healthcare. Malawi's economy is predominantly agrarian, with over 80% of the workforce engaged in agriculture, leaving the economy highly vulnerable to climatic shocks. The GDP per capita was $1,830 in 2023, with a modest projected GDP growth rate of 1.8% for 2024, which is insufficient to match population growth, indicating a potential decline in per capita income[1,2]. The socio-economic challenges exacerbate systemic barriers to healthcare delivery, especially in maternal health.

Malawi's healthcare system provides free facility-based care to residents, though out-of-pocket expenses remain a significant burden, particularly in rural areas[3]. The Christian Health Association of Malawi (CHAM) plays a critical role in complementing public healthcare services, especially in remote areas, while traditional healers continue to deliver health services, though they are not fully integrated into the formal health system. Primary healthcare is predominantly delivered by non-physician clinicians, such as Medical Assistants and Clinical Officers, with district and regional facilities providing secondary and tertiary care[4]. However, geographic, and infrastructural challenges significantly limit access to healthcare, particularly for rural populations who often face long travel distances and poor road conditions.

Despite notable progress in maternal health over the past decade, Malawi continues to face significant challenges. The maternal mortality ratio (MMR) declined from 675 per 100,000 live births in 2010 to 381 in 2020 [5]., a reduction largely attributed to increased contraceptive use, expanded emergency obstetric care, and a rise in skilled birth attendance from 71% to 90% [5].. Nonetheless, the MMR remains among the highest globally, with rural populations disproportionately affected. These inequities are compounded by the persistent burden of

obstetric fistula—a debilitating complication of childbirth that reflects failures across the maternal care continuum.

While obstructed labour remains the leading cause, a growing proportion of cases in sub-Saharan Africa, including Malawi, are iatrogenic in origin. For this study, an iatrogenic fistula was defined as a genitourinary fistula resulting from surgical intervention—most commonly caesarean section or hysterectomy—where documentation confirmed intraoperative injury or the timing was consistent with a surgical cause. Such cases were categorised separately from those due to obstructed labour, enabling a more nuanced interpretation of surgical outcomes, prevention strategies, and the interplay between access to care and surgical safety.

This study employs a rigorous convergence mixed-methods framework to explore the clinical and geospatial determinants of obstetric fistula in Malawi. Combining clinical data, geospatial analyses, and statistical modelling, the research adopts a phased approach to systematically build evidence and generate actionable insights. This phased methodology ensures a comprehensive understanding of maternal health disparities in Malawi. By synthesizing clinical, population-level, and spatial data, the research provides robust evidence to guide policy and programmatic decisions. The integration of GIS, demographic data, and qualitative insights highlights the interplay of geographic, systemic, and social factors in shaping maternal health outcomes. This approach not only addresses critical knowledge gaps in obstetric fistula research but also aligns with global best practices in maternal health research, offering a model for addressing similar challenges in other low-resource settings.

3.2 Study Design

This thesis adopts a convergence (triangulated) mixed-methods approach, integrating **quantitative**, **geospatial**, and **clinical data** sources to examine the preparedness of Malawi's health system to prevent and manage obstetric fistula. The study is structured around the **Three Delays Model**, using four interlinked empirical papers (Phases 1–4), each building upon the insights of the preceding phase to sequentially evaluate barriers across the continuum of maternal care.

The phases are summarized as follows:

1. **Phase 1:** Geospatial Analysis in Maternal Health **(Foundational GIS Paper)** This phase introduces **Geographic Information Systems (GIS)** to map the spatial

distribution of maternal health facilities, identify regional disparities in access, and establish a spatial framework for subsequent analyses. It provides a foundational geospatial context without focusing directly on the Delays Model.

2. **Phase 2: Delay 1** Through **ANC Coverage and Fistula Burden (Paper 1)** This phase uses national survey data (DHS and MICS) integrated with GIS overlays to assess the relationship between **antenatal care (ANC) coverage** and **obstetric fistula prevalence**. ANC attendance is used as a **proxy for the First Delay**, reflecting the decision to seek care.
3. **Phase 3: Delay 2 – Geospatial Inequities in Access to Fistula Repair (Paper 2)** This phase addresses the **Second Delay**—reaching care—by analysing **geographic accessibility** to fistula repair services. GIS-based travel-time modelling and equity indices (e.g., Lorenz curves, Gini coefficients) are used to assess spatial inequities in service distribution and propose decentralization strategies.
4. **Phase 4: Delay 3 – Clinical Outcomes of Fistula Repair (Paper 3)** Using facility-based data from Bwaila Fistula Centre, this phase examines **clinical predictors of surgical success and failure**, with particular attention to factors such as fistula duration, obstructed labour, and antenatal care history. This phase corresponds to the **Third Delay**, focusing on the quality and adequacy of care received.

This structured, sequential design enables a comprehensive examination of how **systemic**, **geographic**, and **clinical barriers** interact across all three delays, supporting an integrated understanding of maternal health inequities and informing strategic policy interventions for fistula prevention and management in Malawi.

3.3 Data Sources

This study employed a diverse range of complementary datasets, integrating clinical, demographic, and geospatial information to comprehensively explore maternal health inequities and determinants of obstetric fistula in Malawi. The combination of the datasets created a multidimensional framework that provided detailed insights into systemic, spatial, and clinical factors impacting maternal health. This holistic approach underscored the interconnected nature of the determinants while offering actionable insights tailored to Malawi's unique context.

A. National Fistula Centre Dataset (2012–2023) (see appendix)

The National Fistula Centre dataset, covering over 11 years and documenting more than 3,000 fistula repair cases, formed the cornerstone of this research. It provided detailed clinical data, including patient demographics, obstetric histories, surgical outcomes, and geographic information. The dataset highlighted obstructed labour as a primary cause of fistula and barriers to care, such as financial constraints, travel distances, and stigma. Its longitudinal nature allowed for the analysis of trends in fistula care and outcomes, offering a rare perspective on the systemic challenges affecting maternal health over time.

B. Malawi Demographic and Health Survey (DHS) 2015–16

The DHS provided nationally representative data on maternal health indicators, including ANC utilization, skilled birth attendance, and obstetric fistula prevalence. Conducted across 24,562 women aged 15–49 years from 850 clusters, the survey captured disparities in ANC timing, frequency, and quality. Its geocoded clusters enabled GIS-based analyses to map healthcare access and identify underserved regions. This dataset complemented the clinical data by offering a broader population-level perspective, enriching the understanding of systemic barriers to maternal healthcare. Qualitative themes were analysed to contextualize systemic bottlenecks and care-seeking behaviours, particularly for women affected by obstetric fistula.

C. Malawi 2019–20 Multiple Indicator Cluster Survey (MICS)

The MICS offered additional insights into maternal health, particularly ANC utilization, skilled delivery, and barriers to care. Conducted across 26,882 households, with a 96% response rate among women aged 15–49 years, it revealed that while 97% of women attended at least one ANC visit, only 51% completed four or more visits. The findings highlighted critical gaps in service utilization, especially in rural areas, and underscored significant inequities in maternal health outcomes. The MICS provided a richer understanding of socioeconomic and geographic disparities, complementing the broader findings from the DHS.

D. Master Health Facility List (2022)

The Master Health Facility List catalogued healthcare facilities in Malawi, detailing their type, ownership, capacity, and geolocation. This dataset was essential for mapping healthcare infrastructure and analyzing facility density, revealing stark urban-rural disparities. GIS analyses based on this dataset enabled precise mapping of healthcare accessibility, travel

times, and underserved regions. Combined with demographic data, it provided an in-depth understanding of systemic barriers to maternal healthcare, particularly for obstetric fistula care.

E. Geospatial Data from MASDAP

The Malawi Spatial Data Platform (MASDAP) supplied high-resolution geospatial datasets, including shapefiles of administrative boundaries, road networks, and population density maps. The datasets were instrumental in spatial analyses, enabling evaluations such as travel time estimation to healthcare facilities, service area mapping to identify underserved regions, and hotspot analysis to detect areas with high burdens of healthcare inequities. MASDAP's open-access platform facilitated seamless integration with other datasets, enhancing the ability to address systemic and geographic disparities in maternal healthcare and guide targeted interventions.

3.3 Integration and Uniqueness of the Approach

The integration of the datasets created a unique and multidimensional analytical framework that distinguishes this research. The clinical insights from the National Fistula Centre dataset were complemented by the population-level data from the DHS and MICS, offering a comprehensive view of both individual and systemic challenges. The Master Health Facility List and MASDAP geospatial data added critical spatial dimensions, enabling advanced GIS analyses to map healthcare accessibility and equity. Spatial analysis using GIS was integrated with DHS survey and clinical data to model geospatial accessibility and identify facility catchments relevant to maternal care service readiness.

This layered approach allowed for the exploration of maternal health from multiple perspectives—clinical, demographic, and geographic—providing a more holistic understanding of the interplay between healthcare access, maternal health outcomes, and systemic barriers. The longitudinal nature of the clinical dataset, combined with the breadth of population-level surveys and the precision of geospatial analyses, ensured that this research captured both the macro-level trends and micro-level intricacies of maternal health in Malawi.

This unique combination of datasets provided a robust foundation for the research, enabling a comprehensive analysis of maternal health inequities in Malawi. By integrating clinical, population, and spatial data, the study not only enriched the understanding of systemic and geographic barriers but also generated actionable insights to inform targeted interventions and policy decisions. This multidimensional methodology stands out as a model for addressing complex public health challenges in resource-limited settings.

3.4Spatial and Statistical Analysis Techniques

Spatial Analysis Techniques

Spatial analyses were central to this study, providing critical insights into geographic disparities in healthcare access. Using ArcGIS Pro (Version 3.2.0, ESRI, Redlands, CA), a range of geospatial tools were employed to explore healthcare inequalities. Travel time estimation, based on road networks and terrain data, quantified accessibility to healthcare facilities. Hotspot analysis, utilizing the Getis-Ord Gi* statistic, identified clusters of high obstetric fistula prevalence. Service area mapping delineated healthcare catchment zones, highlighting underserved regions. Kernel density estimation further assessed the distribution of healthcare facilities relative to population density, offering a comprehensive evaluation of spatial disparities. The geospatial techniques enabled precise visualization and assessment of systemic gaps, informing targeted interventions for maternal health.

Statistical-Analysis

Advanced statistical methods, supported by robust analytical tools, were employed to ensure the reliability and depth of the findings. Descriptive statistics, conducted in Stata (Version 17), provided a foundational understanding of patterns across variables such as antenatal care (ANC) coverage, facility density, and fistula prevalence. Multivariate logistic regression models were applied to explore associations between maternal health outcomes and predictors like ANC utilization, controlling for potential confounding factors. This approach facilitated nuanced interpretations of clinical and demographic relationships.

Geographically Weighted Regression (GWR), executed in ArcGIS Pro, enabled localized analyses that accounted for spatial variability, offering insights into geographic and contextual disparities. Scenario modelling, conducted in R (Version 4.2), simulated the effects of potential public health interventions, such as scaling ANC4+ coverage. The simulations evaluated the projected impact of interventions on maternal health outcomes, providing evidence for policy

and programmatic planning. By integrating clinical, geospatial, and demographic data across multiple platforms, this study achieved a rigorous interdisciplinary approach, ensuring comprehensive and actionable insights into maternal health disparities.

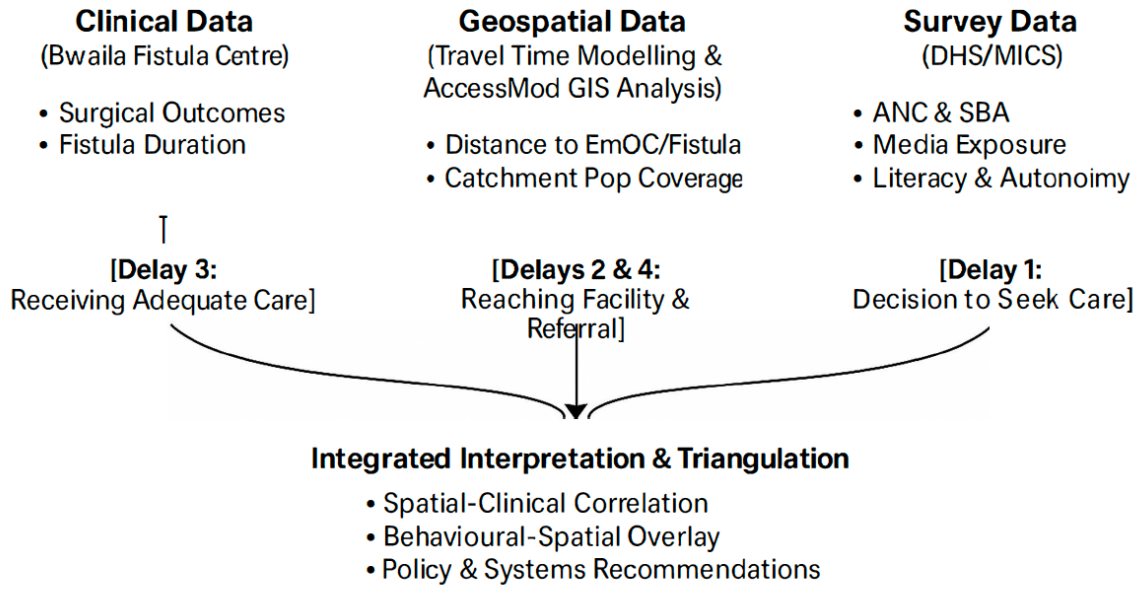
3.5 Scientific Basis for a Mixed-Methods Approach

This study adopts a convergent mixed-methods design that integrates quantitative, clinical, and geospatial analyses to generate a comprehensive understanding of maternal health disparities and the burden of obstetric fistula in Malawi. The approach combines the statistical precision of quantitative epidemiology with the spatial intelligence of Geographic Information Systems (GIS), thereby bridging individual-level clinical outcomes with population-level health system dynamics. Quantitative analyses draw on surgical audit data, demographic surveys, and health service coverage indicators to identify predictors of obstetric fistula occurrence and repair outcomes. In parallel, GIS-based modelling—using tools such as ArcGIS, WHO Access Mod—maps physical accessibility to emergency obstetric and fistula repair services, estimates travel times, and identifies geographic inequities in care distribution.

By triangulating these datasets within the **Three Delays Model** framework, the methodology captures both structural and systemic barriers, including sociocultural determinants (Delay 1), geographic and infrastructural constraints (Delay 2), and facility readiness and quality of care (Delay 3). This integration enables the identification of spatial "hotspots" of need, informs targeted interventions, and supports strategic resource allocation. The approach aligns with global best practices in health systems research and health geography, providing an evidence base for policy, planning, and programmatic action in resource-limited settings. Figure 6 presents the convergent mixed-methodology framework applied in this study, illustrating how clinical, geospatial, and survey data are integrated to inform interpretation, triangulation, and actionable recommendations.

The framework integrates three primary data sources—clinical audit data from the Bwaila Fistula Centre (Delay 3: receiving adequate care), geospatial accessibility modelling (Delays 2 & 4: reaching facility and referral), and national survey datasets (DHS/MICS) capturing sociocultural and health-seeking determinants (Delay 1: decision to seek care). These data streams are analysed concurrently and triangulated to identify correlations between spatial, behavioural, and clinical factors, enabling evidence-based recommendations for policy and health system strengthening in Malawi.

Figure 7Convergent mixed methodology framework



3.6 Ethical Considerations

This study adhered to the highest ethical standards in public health research, aligning with international frameworks and local regulatory requirements. Ethical approval was obtained from the **University of Cape Town Human Research Ethics Committee (HREC)** under **Protocol No. HREC/744/2022/ (appendix 1)** , ensuring compliance with institutional research integrity standards. The study also conformed to the ethical regulations of Malawi's **National Health Sciences Research Committee (NHSRC) with** Lilongwe District Health Office Research Ethics Approval (Appendix 2) to uphold the principles of responsible research in the local context. All components of the study were ethically approved and structured to allow cross-validation between clinical audits, population-level data, and spatial modelling.

Ethical Approvals and Adherence to Guidelines

In line with the **Declaration of Helsinki**, the study ensured that all data were collected, analysed, and reported ethically and responsibly. Only secondary data from reputable sources were utilized, with explicit permissions and access agreements where required:

- **National Fistula Centre dataset**: Accessed through formal institutional collaboration and approval, with strict measures in place to ensure the protection of patient confidentiality.
- **DHS and MICS datasets**: Publicly available data were used under their respective data-use agreements, ensuring compliance with established terms.
- **MASDAP geospatial data**: Open-access datasets were utilized in accordance with their terms of use, enabling advanced spatial analyses of healthcare accessibility.

Data Protection and Confidentiality

To safeguard participant privacy, all datasets were anonymized prior to analysis. The **National Fistula Centre dataset**, which contains over a decade of clinical records on fistula repair outcomes, was de-identified to eliminate sensitive patient identifiers while preserving analytical value. Similarly, publicly available datasets like **DHS**, **MICS**, and **MASDAP** adhered to international standards for secure data handling and anonymization. The research followed **UCT's research data management policy**, ensuring proper documentation, storage, and usage of all datasets.

Ensuring Research Integrity

This study did not involve the collection of primary data, instead focusing exclusively on the secondary analysis of high-quality datasets. This approach minimized risks to individuals while leveraging existing data to provide insights into maternal health disparities in Malawi. The combination of clinical, demographic, and geospatial data sources strengthened the analytical rigor and reliability of findings, enabling a multidimensional understanding of the systemic, geographic, and clinical determinants of obstetric fistula.

Conclusion

By adhering to ethical guidelines from UCT, NHSRC, and international frameworks such as the **Declaration of Helsinki**, this study exemplifies ethical and responsible research practices. The comprehensive use of secondary data from reputable sources enhances the robustness of findings while rigorous data protection measures safeguard individual confidentiality. The ethical foundations underpin the study's contribution to advancing evidence-based strategies for improving maternal health outcomes in Malawi.

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PART II: EMPIRICAL FINDINGS AND THEMATIC INSIGHTS

CHAPTER 4: GEOSPATIAL ANALYSIS IN MATERNAL HEALTH

4.1 Overview of the study

This chapter presents a refined exploration of the critical role of Geographic Information Systems in addressing maternal health disparities, with a particular focus on Malawi. Maternal health outcomes are deeply influenced by geographic barriers, systemic inefficiencies, and inequitable distribution of healthcare services. GIS has emerged as an essential tool in mapping healthcare access gaps, optimizing service delivery, and informing policy decisions in low-resource settings. This chapter provides an in-depth review of the application of spatial data in maternal health research, emphasizing how spatial analytics, predictive modelling, and network analysis can improve antenatal care (ANC) coverage, skilled birth attendance, and access to emergency obstetric care (EmOC) and fistula repair services.

A range of spatial methodologies are discussed, including travel-time analysis, spatial clustering, and facility optimization**,** which are particularly effective in identifying healthcare inequities. Travel-time analysis quantifies accessibility constraints by measuring distances and estimated transport times to maternal health facilities, highlighting underserved populations. Spatial clustering techniques pinpoint geographic hotspots of poor maternal health outcomes, allowing targeted interventions where they are most needed. Facility optimization models use GIS to strategically guide the placement of maternal health facilities and redistribute healthcare resources for maximum impact. These techniques provide data-driven insights that can enhance emergency referral systems, optimize workforce allocation, and guide evidence-based maternal healthcare planning**.**

The chapter further contextualizes the use of GIS within Malawi's maternal health landscape, detailing the stark rural-urban disparities in service access. Poor road networks, centralized healthcare infrastructure, and a shortage of skilled maternal health workers continue to limit equitable healthcare distribution. GIS can bridge these gaps by offering real-time spatial mapping of service shortages, improving ambulance and emergency obstetric transport networks, and guiding the expansion of fistula repair services to high-burden areas. While GIS presents a transformative opportunity for improving maternal healthcare, data quality constraints, privacy concerns, and technical capacity limitations remain key challenges to its full implementation in Malawi's health system. Addressing these issues requires strategic

investments in data infrastructure, policy frameworks for ethical GIS use, and workforce capacity-building initiatives.

This chapter serves as the foundation for the empirical studies that follow in the thesis, linking geospatial disparities to clinical maternal health outcomes. By integrating GIS methodologies with maternal health research, this study advocates for a systemic, data-driven approach to improving maternal healthcare in Malawi. The evidence presented underscores the potential of GIS to revolutionize maternal health service delivery, strengthen health system resilience, and support policy interventions that ensure equitable access to life-saving care for all women**.**

GEOSPATIAL INTELLIGENCE IN MATERNAL HEALTH: JUSTIFYING GIS FOR EQUITABLE ACCESS AND SURGICAL CARE IN MALAWI

4.2 Introduction: Bridging Methodological Approaches in Maternal Health Research

Maternal health inequities remain a critical global health challenge, particularly in low- and middle-income countries (LMICs), where geographic, socio-economic, and systemic barriers significantly impact healthcare access and outcomes. Despite global initiatives such as the Sustainable Development Goals (SDGs) and Every Woman, Every Child movement, maternal mortality rates remain disproportionately high in sub-Saharan Africa (SSA), which accounts for more than two-thirds of global maternal deaths [1]. While progress has been made in antenatal care (ANC) coverage, skilled birth attendance, and emergency obstetric care (EmOC), persistent geographic disparities continue to hinder equitable access to maternal healthcare services.

Traditional maternal health research relies on methodologies such as demographic health surveys (DHS), facility-based assessments, and population health studies. While effective for tracking maternal health indicators, these approaches lack spatial granularity, fail to integrate geographic healthcare access constraints, and often rely on long data collection cycles (5–10 years), making them inadequate for real-time decision-making [2]. The increasing availability of spatial epidemiology and spatial data presents an opportunity to bridge this gap by integrating geospatial intelligence into maternal health planning.

Unlike conventional statistical models, Geospatial data provides a spatial perspective on health disparities, allowing researchers and policymakers to visualize service distribution, analyze geographic access barriers, and optimize resource allocation [3].By integrating spatial epidemiology, predictive modelling, and health systems research, they strengthen evidence-based decision-making and ensures that maternal health interventions target high-risk regions effectively. This study builds upon these advancements by applying GIS methodologies to explore maternal healthcare accessibility, service distribution, and surgical care planning in Malawi.

Establishing the Rationale for GIS in Maternal Health Research

Maternal mortality remains a persistent global health challenge, especially in SSA, where disparities in emergency obstetric care, antenatal coverage, and skilled birth attendance undermine progress toward SDG 3.1—reducing maternal mortality to fewer than 70 deaths per 100,000 live births[4,5]. Despite a 38% decline in maternal mortality between 2000 and 2020, SSA still reports maternal mortality ratios (MMRs) exceeding 500 per 100,000 live births, significantly higher than the global target. In contrast, Eastern European countries have achieved a decline in MMR from 38 to 11 deaths per 100,000 live births, demonstrating the potential impact of well-distributed maternal health services and emergency care [1,6].

Several key factors contribute to these persistent disparities in maternal mortality, including geographic isolation of rural communities, poor transport infrastructure leading to delays in emergency obstetric referrals, health workforce shortages, and inefficient health facility distribution. These systemic barriers disproportionately impact women in remote regions, exacerbating maternal health disparities. Traditional maternal health research, relying primarily on demographic health surveys (DHS), facility-based assessments, and population health studies, has been instrumental in tracking maternal health indicators. However, these methods fail to capture spatial variations in healthcare accessibility, limiting their effectiveness for planning targeted interventions [6].

Limitations of Traditional Maternal Health Research

Current maternal health research methodologies do not fully address spatial disparities, highlighting the need for geospatial methodologies. Traditional approaches such as epidemiological surveys (e.g., DHS, Multiple Indicators Cluster Survey (MICS), WHO maternal mortality estimates) provide national-level maternal health indicators but lack localized spatial detail for effective healthcare planning. These surveys do not integrate geographic access barriers, such as road networks, terrain variations, or facility density, and their long data collection cycles make them unsuitable for real-time decision-making.

Health systems research primarily focuses on service availability and workforce distribution but does not quantify geographic barriers that prevent maternal healthcare utilization. Additionally, statistical modelling approaches, while useful for estimating maternal health determinants, often fail to incorporate travel-time dynamics or spatial clustering of maternal health disparities [2]. These limitations highlight the need for GIS-driven research that provides a spatially explicit understanding of maternal health inequities.

The Need for a GIS-Based Approach

To address these methodological gaps, GIS enables a spatially-driven analysis of maternal health inequities, shifting from static epidemiological reporting to dynamic spatial modelling. It further provides several key advantages in maternal health research, including real-time spatial mapping of maternal health service gaps, travel-time modelling to quantify geographic accessibility constraints, identification of high-risk clusters for maternal morbidity and mortality, and optimization of healthcare resource allocation through workforce deployment and facility placement.

By leveraging these capabilities, GIS transforms maternal health research from descriptive reporting to actionable geospatial intelligence, improving data-driven decision-making in maternal healthcare planning. This study will apply spatial methodologies to analyze ANC coverage, emergency obstetric care accessibility, and maternal morbidity patterns in Malawi, providing a comprehensive geospatial assessment of maternal health service distribution.

Transitioning from Traditional Methods to GIS-Driven Research

This study employs an integrated multi-method approach to maternal health research, combining descriptive epidemiology, health systems research, and spatial epidemiology using GIS. By integrating these methodologies, this research provides a comprehensive framework for identifying and addressing maternal health disparities, optimizing service delivery, and informing evidence-based maternal healthcare planning.

Why GIS? Methodological Significance in This Study

Within the context of the Three Delays model, the integration of spatial data in this study serves as a complementary analytical tool—providing spatial insights into where delays in accessing maternal care may be concentrated. Rather than positioning GIS as a solution, this approach uses spatial analysis to enhance understanding of health system reach and the geographic distribution of maternal services in Malawi.

GIS was applied to explore spatial disparities in antenatal care coverage, the location of fistula treatment services, and potential barriers to emergency obstetric referrals. These visual and analytic outputs support the identification of areas where the second delay—reaching care—may be most pronounced. However, the study recognizes the limitations of spatial proximity

as a proxy for effective access. Facilities that appear geographically close may remain inaccessible due to systemic factors such as limited staffing, poor quality of care, or inefficient referral systems.

By situating geospatial data within the broader structure of the delays model, this study leverages geospatial evidence to complement, rather than replace, clinical, sociocultural, and policy analysis. In doing so, it offers a more integrated and context-sensitive understanding of maternal healthcare access and equity in Malawi.

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Aligning GIS Research with Global Maternal Health Priorities

Incorporating spatial methodologies into maternal health research aligns with global health frameworks, including the WHO Global Strategy for Women's, Children's, and Adolescents' Health (2016–2030)[7], which advocates for spatial analytics in maternal healthcare planning, the Lancet Commission on Global Surgery (2015) [8], which emphasizes geospatial assessments for surgical equity and access, and the UNFPA Ending Fistula Initiative [5], which supports GIS-driven needs assessments for fistula treatment programs.

This study transitions to spatial-based analysis by systematically assessing spatial disparities in ANC coverage, skilled birth attendance, and access to fistula care, modelling travel-time barriers to emergency obstetric care, mapping geospatial clusters of maternal morbidity, and optimizing health facility placement and workforce distribution. These geospatial analyses will provide a data-driven foundation for strengthening Malawi's maternal healthcare system, ensuring that resources are effectively allocated to high-burden regions and maternal health interventions are spatially optimized.

The Evolution of Geospatial Health Research

The application of spatial data in healthcare has evolved significantly over the past four decades. Initially, GIS was primarily utilized for infectious disease surveillance, with early examples including John Snow's 1854 cholera map, which identified the Broad Street water pump as the contamination source [9]. As spatial epidemiology developed, it expanded beyond infectious diseases to include broader health system planning, service accessibility assessments, and healthcare infrastructure optimization [2].

In maternal health, spatial data has become an indispensable tool for understanding healthcare inequities, identifying service gaps, and informing resource allocation. Early applications of spatial analysis in maternal health research focused on mapping healthcare facility distribution in relation to population density. Studies in SSA revealed stark mismatches between infrastructure and maternal health needs, where facilities were often concentrated in urban centres, leaving vast rural populations underserved[10]. In addition, geospatial-based travel-time modelling quantified geographic barriers to emergency obstetric care, with findings showing that more than 50% of rural women in West and East Africa lived beyond the WHO-recommended two-hour travel time to a Comprehensive Emergency Obstetric Care (CEmOC) facility [11].

As spatial epidemiology has advanced, it has moved beyond simple facility mapping to include complex analytical techniques such as predictive modelling, health system optimization, and geostatistical clustering of maternal health outcomes [12]. Modern GIS applications in maternal health research now enable policymakers to anticipate service gaps, optimize referral pathways for emergency obstetric care, and integrate demographic health data with health infrastructure planning[13]. The increasing sophistication of spatial technology—including AI-driven spatial analysis, real-time monitoring, and mobile health integration—has positioned GIS as a transformative tool for maternal health planning globally.

A key question remains: how can the successes of spatial analytics applications in global maternal health be translated into **actionable interventions for Malawi**? The next section explores country-specific GIS interventions that have demonstrated tangible improvements in maternal health outcomes.

4.3 GIS as a Decision-Support Tool in Global Maternal Health

The application of GIS in maternal health has yielded significant improvements in health system planning and service delivery, particularly in low-resource settings. Several country-specific initiatives illustrate its transformative role in optimizing maternal healthcare access. While GIS provides valuable insights, it should be viewed as a decision-support tool rather than a solution to systemic health inequities

Ethiopia: GIS-Driven Facility Placement and Travel-Time Reduction

Ethiopia has been a leader in GIS-integrated maternal healthcare planning. The country's Health Sector Transformation Plan incorporated GIS-driven facility placement models to reduce travel times for obstetric emergencies [14].GIS modelling identified geographic gaps in CEmOC services, particularly in Afar and Somali regions, where travel times to the nearest Caesarean-section-capable facility exceeded four hours. In response, Ethiopia strategically established new maternal health centres in high-burden rural areas, reducing emergency delivery travel times by up to 40%. This GIS-driven facility expansion led to a measurable increase in institutional deliveries and a decline in maternal mortality rates.

Nigeria: GIS in Fistula Service Delivery

Nigeria, home to the highest global burden of obstetric fistula, has leveraged GIS to improve access to fistula repair services. Historically, fistula repair centres were concentrated in urban tertiary hospitals, limiting access for rural women in high-prevalence states such as Kano, Sokoto, and Borno [15]. GIS-based fistula burden mapping identified priority regions with the highest unmet surgical needs, leading to the introduction of mobile GIS-tracked fistula surgical camps in remote northern states. Between 2015 and 2020, these GIS-mapped interventions increased the number of fistula repairs performed annually by 35%, demonstrating the power of spatial analytics in optimizing surgical outreach programs [15].

Tanzania: GIS-Optimized Maternal Referral Networks

One of the greatest barriers to maternal health in Tanzania has been delays in emergency obstetric referrals, often due to long distances, poor road conditions, and uncoordinated transport systems[3] . A national GIS-based referral network optimization study in Tanzania reconfigured maternal transport systems by mapping health facility locations and overlaying road network data. Using GIS simulation models, the study optimized ambulance deployment, ensuring faster transfers to higher-level obstetric care centres. Additionally, real-time GIS monitoring allowed hospitals to track patient movements and predict facility congestion. The results demonstrated a 30% reduction in emergency transport time for obstetric complications and a 15% increase in maternal survival rates in rural districts where timely referrals had previously been a challenge [16].

Geospatial modelling in Mozambique and Ethiopia demonstrates the impact of targeted health interventions. In Mozambique, upgrading 37 strategically located facilities for cesarean

delivery could enable 4% more of the population (about 968,846 people) to access higher-level care within two hours[17]. In Ethiopia, similar improvements could enhance access for an additional 8.6 million people[14]. These findings highlight the role of data-driven strategies in optimizing healthcare infrastructure and improving maternal health outcomes. The analysis should be interpreted in conjunction with contextual factors such as facility readiness, workforce availability, and community-level barriers

These case studies highlight common challenges—such as poor infrastructure, workforce shortages, and transport inefficiencies—that GIS has helped address. However, successful implementation has depended on strong governmental support, sustainable funding, and robust data systems. As Malawi looks to integrate GIS into maternal health planning, these experiences offer valuable lessons on how to overcome geographic disparities and optimize resource distribution.

4.4 GIS Integration into Malawi's Maternal Health Planning

The lessons from Ethiopia, Nigeria, Mozambique, and Tanzania underscore the potential of GIS to transform maternal health service delivery in Malawi. Despite efforts to improve maternal healthcare, Malawi continues to face significant geographic and infrastructural challenges. Wide rural-urban disparities in maternal health service accessibility persist, with rural women disproportionately affected by long travel times, inadequate healthcare infrastructure, and limited emergency obstetric care options.

Several key barriers to GIS adoption in Malawi must be addressed. First, data quality and availability remain significant challenges, as maternal health records often lack geospatial detail, limiting the effectiveness of GIS-based planning. Second, the shortage of GIS-trained technicians presents an obstacle to widespread adoption of geospatial health interventions. Finally, policy frameworks supporting the integration of GIS into national health strategies are still underdeveloped, requiring greater institutional commitment and investment.

To address these challenges, this study will apply GIS methodologies to:

- **Assess spatial disparities** in antenatal care (ANC) coverage, skilled birth attendance, and access to fistula care.

- **Model travel-time barriers** to emergency obstetric care, identifying geographic constraints that impact timely healthcare access.
- **Map geospatial clusters** of maternal morbidity, including obstetric fistula prevalence, to highlight high-burden regions requiring targeted interventions.
- **Optimize health facility placement and workforce distribution** to ensure equitable resource allocation and improve maternal health outcomes.

By leveraging **GIS-driven insights**, Malawi can develop **evidence-based maternal health policies** that improve service accessibility, optimize emergency obstetric care, and reduce maternal mortality. This transition marks the methodological pivot in this research, demonstrating how GIS-driven maternal health strategies can be contextualized for Malawi.

Enhanced GIS-Driven Framework for Maternal Health in Malawi

Malawi, with its persistent maternal health disparities, stands to benefit significantly from GIS-driven interventions that optimize healthcare access, workforce distribution, and service delivery efficiency. The following sections expand on the methodological advancements in GIS application while integrating policy-oriented recommendations for improving maternal healthcare outcomes in Malawi.

Travel-Time Analysis

Travel-time analysis is a critical GIS methodology used to evaluate maternal healthcare accessibility by quantifying the time required for pregnant women to reach essential health facilities. This approach considers various geographic and infrastructural factors, including distance, terrain, road conditions, and transportation availability. Studies have demonstrated that long travel times significantly impact access to maternal health services, particularly in sub-Saharan Africa, where many women live beyond the WHO-recommended two-hour threshold for reaching CEmOC facilities. Research in Lagos, Nigeria, has highlighted how urban congestion further exacerbates delays, while rural areas struggle with inadequate transport infrastructure [11,18,19]. GIS-based travel-time mapping is instrumental in identifying these gaps, allowing policymakers to allocate resources effectively and prioritize infrastructure improvements in underserved regions. Findings indicate that poor road networks, limited transport options, and an uneven distribution of healthcare facilities are key contributors to delayed maternal healthcare access, emphasizing the need for spatially informed interventions

[14]. These spatial findings must be cautiously interpreted given that physical proximity does not equate to functional access in the absence of quality services.

Spatial Clustering

Spatial clustering is a powerful geospatial analytical method that allows researchers to detect and analyze geographic concentrations of adverse maternal health outcomes, such as high rates of maternal morbidity and mortality. This technique is essential for identifying regions where maternal health challenges are disproportionately severe, helping to uncover patterns that may not be evident through traditional epidemiological assessments.

One of the most widely used tools in spatial clustering is SaTScan software, which applies statistical methods to detect spatial and spatiotemporal clusters of health outcomes. By identifying high-risk geographic zones, spatial clustering provides critical insights into the geographic distribution of maternal health disparities, guiding targeted interventions where they are most needed. The ability to pinpoint specific areas with a high burden of maternal health issues, including low antenatal care coverage, high rates of obstetric complications, and poor access to emergency obstetric care, is invaluable for informing public health strategies.

Beyond identifying hotspots, spatial clustering is instrumental in optimizing resource allocation. Once high-risk areas are identified, policymakers can deploy maternal health resources more effectively, ensuring that health services, skilled personnel, and emergency obstetric care reach the populations that need them most. For instance, if a particular district exhibits a disproportionately high rate of maternal deaths due to long travel distances to health facilities, interventions can be strategically designed to improve facility accessibility, enhance transport networks, or expand community-based maternal health programs.

Findings from global maternal health research have demonstrated that spatial clustering is not only useful in recognizing inequities but also in monitoring the effectiveness of interventions over time[20,21]. By continually analyzing maternal health trends, policymakers can evaluate whether targeted interventions, such as the establishment of new health facilities or the introduction of mobile maternal health services, are effectively addressing gaps in service delivery. Additionally, spatial clustering can help in prioritizing areas for fistula prevention and repair services, ensuring that the most vulnerable populations—often located in remote or under-resourced regions—are adequately served.

GIS-Based Facility Optimization

GIS-based facility optimization enhances maternal healthcare by strategically placing health centres in underserved areas, reducing travel times, and improving access to emergency obstetric care. By analyzing population density, facility distribution, and transport networks, GIS identifies healthcare deserts**,** guiding targeted investments to maximize healthcare impact[21,22]. This approach is particularly vital in LMICs like Malawi, where geographic inaccessibility remains a major barrier to maternal health services.

Beyond facility placement, it improves service efficiency by redistributing healthcare resources to overburdened centres and optimizing referral pathways for obstetric emergencies. Spatially-driven ambulance dispatch models reduce transport delays, improving maternal survival rates. Additionally, it can aid in fistula care planning by identifying optimal locations for regional surgical hubs, addressing the centralization of specialized services. Integrating spatial data into maternal health policy fosters equitable, data-informed health systems*,* ensuring life-saving care reaches the most vulnerable populations.

4.5 Policy-Oriented GIS Implementation in Malawi's Maternal Health System

For GIS findings to translate into impactful maternal health policies, structured implementation strategies must be developed. The Ministry of Health in Malawi should integrate GIS analytics into national health planning frameworks, leveraging spatial intelligence to improve emergency obstetric care, optimize workforce distribution, and guide health facility expansion.

A crucial policy application of GIS is the enhancement of emergency transport networks. Malawi's maternal health challenges are heavily influenced by geographic barriers, particularly for rural populations who experience delays in seeking, reaching, and receiving care. Poor transport networks, long travel times, and centralized maternal health services contribute to inequitable access to ANC, emergency obstetric care, and fistula treatment[23–25]. GIS provides spatial intelligence to map health facility distribution, assess travel-time constraints, and guide targeted interventions. By leveraging this, health planners and policymakers can develop evidence-based strategies that improve service accessibility, efficiency, and equity, ultimately reducing maternal morbidity and mortality in Malawi.

Furthermore, GIS should be integrated into workforce planning strategies to address the uneven distribution of maternal health professionals. Current workforce shortages in rural areas limit access to skilled birth attendants, midwives, and fistula repair specialists, contributing to preventable maternal complications. A GIS-based workforce deployment model can identify areas with high patient-to-provider ratios and guide targeted workforce redistribution efforts. Incentive programs should be designed to encourage healthcare professionals to serve in underserved regions, with GIS monitoring ensuring effective workforce allocation.

Addressing Challenges to GIS Adoption in Maternal Health Policy

Despite its transformative potential, the integration of spatial analysis into maternal health policymaking faces several challenges. Limited health data quality remains a major barrier, as maternal health records in many low-resource settings, including Malawi, often suffer from incompleteness, outdated information, and inconsistencies in reporting. The lack of standardized spatial health datasets restricts the accuracy and reliability of GIS-driven analyses. Additionally**,** privacy concerns pose ethical and legal challenges, particularly in handling sensitive patient data such as antenatal care attendance, birth outcomes, and fistula treatment records**.** Ensuring secure data-sharing frameworks while maintaining patient confidentiality is crucial for the responsible use of spatial data in healthcare planning. A major barrier its adoption in maternal health is the shortage of specialized personnel to analyze and apply geospatial data. Rather than training frontline health workers—whose focus should remain clinical—countries should invest in centralized GIS units within planning departments or partner with academic institutions. This allows for expert-led spatial analysis while ensuring that clinical resources remain focused on patient care[26].

Justification for GIS in Malawi's Maternal Health System

Malawi has one of the highest maternal mortality rates in sub-Saharan Africa (SSA), however there has been a reduction in MMR between years 2000 and 2020 from 573 to 381 per 100,000 live births (WHO, 2023). While efforts have been made to strengthen maternal health services through health sector reforms, emergency obstetric care expansion, and skilled birth attendance promotion, geographic disparities remain a significant determinant of maternal morbidity and mortality.

The spatial distribution of maternal health services in Malawi is highly uneven, with rural districts disproportionately underserved. The application of GIS in maternal health can provide evidence-based planning for healthcare infrastructure, ensuring that health services are strategically placed to optimize accessibility and improve maternal health outcomes.

Key Geographic Challenges in Malawi's Maternal Health System

a) Unequal Distribution of Antenatal Care Services

- Antenatal care is a critical preventive strategy that allows for early detection of pregnancy complications and ensures timely referrals to higher-level facilities.
- Malawi has wide geographic variations in ANC coverage, with rural and remote areas experiencing low ANC attendance and late first visits.
- The WHO recommends at least eight ANC visits per pregnancy, but only 51% of Malawian women attend at least four visits, with even lower adherence in remote regions[27–29].

b) Geographic Barriers to Emergency Obstetric Care

- Timely access to Comprehensive Emergency Obstetric and Neonatal Care (CEmONC) is crucial for preventing maternal deaths related to haemorrhage, obstructed labor, and sepsis.
- More than 40% of Malawian women in rural areas live beyond the WHO-recommended two-hour travel time to CEmONC facilities, resulting in delays in life-saving care[28,29].
- Most referral hospitals are concentrated in urban areas (e.g., Blantyre, Lilongwe, Mzuzu), leaving rural communities at a severe disadvantage.

c) Limited Access to Obstetric Fistula Surgical Services

- Obstetric fistula, a debilitating childbirth injury caused by obstructed labour, remains prevalent in Malawi.
- Surgical repair is the only treatment for obstetric fistula, yet most repair centres are concentrated in Lilongwe and Blantyre, making access difficult for rural patients.
- GIS-based facility optimization could identify optimal locations for regional fistula surgical hubs, reducing travel time barriers and expanding surgical access to

underserved regions. Table 1 below summarises some impacts of the barriers and solutions.

Table 1Geographic Barriers to Emergency Obstetric Care in Malawi *and GIS-Supported Approaches* ***in Malawi***

Barrier	Observed Impact on Maternal Health	GIS-Supported Approach (Aligned with Delay 2)
Long travel times to referral facilities	Delays in receiving emergency obstetric care; risk of obstetric complications	Travel-time modelling to highlight underserved zones
Sparse distribution of EmOC-capable facilities	Limited-service coverage, especially in rural areas	Facility location analysis to support equitable redistribution
Poor road and transport infrastructure	Increased maternal and neonatal mortality; delayed referrals	Mapping transport networks to inform referral pathway planning
Overcrowding at tertiary hospitals	Reduced care quality and longer wait times for surgical care	Catchment area analysis to guide strategic scale-up of mid-level centres
Inadequate referral coordination	Inefficient use of resources; poor outcomes from delayed escalation	Spatial mapping of referral routes and response times

Strategic Roadmap for GIS Integration into Malawi's Maternal Health System

To ensure a structured and sustainable integration of GIS in Malawi's maternal health system, the following roadmap is proposed:

a) **Capacity Building:** Establish GIS training programs for health professionals and policymakers, equipping them with the technical skills necessary for geospatial analysis and decision-making.
b) **Health Data Standardization:** Implement data collection frameworks that ensure consistency, accuracy, and interoperability of spatial health data across national health systems.
c) **GIS-Enabled Facility Planning:** Develop spatial models to guide the expansion of maternal health services, ensuring that new facilities are in areas with the highest need.

d) **Emergency Transport Optimization:** Deploy GIS-assisted ambulance routing systems to enhance emergency obstetric care, reducing delays in maternal health emergencies.
e) **Workforce Redistribution:** Utilize GIS mapping to guide the strategic placement of maternal health professionals, ensuring equitable service distribution.
f) **Policy Integration:** Incorporate GIS analytics into national maternal health policies, ensuring data-driven decision-making in healthcare planning and resource allocation.

By systematically implementing GIS-driven maternal health strategies, Malawi can address critical geographic barriers to healthcare access, optimize resource allocation, and enhance maternal health outcomes. This structured approach ensures that maternal health services reach the populations most in need, reducing disparities and improving overall healthcare equity.

4.6 Conclusion

This chapter has demonstrated that Geographic Information Systems are an indispensable tool in maternal health planning in Malawi, offering a data-driven approach to addressing spatial disparities in healthcare access. By integrating spatial epidemiology into maternal health policy, GIS enables the identification of gaps in antenatal care coverage, emergency obstetric care accessibility, and fistula repair services. Geospatial analytics complements, but does not replace, qualitative and clinical insights needed to guide investments in maternal health services. These geospatial insights can guide evidence-based interventions that optimize facility placement, improve referral networks, and ensure a more equitable distribution of healthcare resources. Given Malawi's high maternal mortality burden, GIS-driven strategies are crucial for reducing the "three delays"—delays in seeking, reaching, and receiving care—which are leading contributors to adverse maternal health outcomes.

The application of GIS in maternal health transport networks has the potential to reduce referral delays and enhance emergency obstetric response systems, particularly in rural and hard-to-reach areas. Additionally, geospatial mapping can support the expansion of fistula repair services by identifying high-burden regions and guiding the establishment of regional surgical hubs to decentralize care. The ability to use GIS for workforce distribution analysis also ensures that maternal health professionals, including midwives, obstetricians, and fistula surgeons, are strategically deployed where they are needed most.

Having established the spatial and health system context, the next three chapters adopt a methodical progression through the Three Delays framework, beginning with Delay 1—care-seeking. This chapter focuses on the first delay using antenatal care (ANC) attendance as a proxy indicator of early engagement with the health system. ANC utilization reflects not only health-seeking behaviour but also underlying sociocultural, informational, and systemic barriers to timely care initiation. By examining patterns of ANC attendance across Malawi, this chapter interrogates how early maternal health contact varies by region and population group, providing a window into the complex dynamics of care-seeking. This is followed in subsequent chapters by an in-depth geospatial analysis of Delay 2 (reaching care) and a clinical audit of Delay 3 (receiving appropriate care), using surgical outcomes as a measure of service effectiveness. Together, these chapters offer an integrated and sequential understanding of where, why, and how delays in maternal care occur—linking individual-level decisions with system-wide accessibility and clinical readiness. This structured approach ensures that the spatial evidence presented in earlier chapters is translated into actionable insights across the continuum of maternal care.

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CHAPTER 5: ANTENATAL CARE COVERAGE AND FISTULA BURDEN -EXPLORING DELAY 1

5.1 Overview of the Chapter

This chapter initiates the analytical exploration of the **First Delay** in the Three Delays Model—**the delay in deciding to seek care**—by using **antenatal care coverage as a proxy indicator**. This approach focuses not on primary qualitative inquiry but rather on leveraging **secondary data from nationally representative surveys**—notably the **Malawi Demographic and Health Survey (DHS)** and the **Multiple Indicator Cluster Survey (MICS)**—to examine patterns in ANC utilization and their relationship to obstetric fistula prevalence.

The study does **not incorporate new qualitative fieldwork** on sociocultural determinants of care-seeking. Instead, it synthesizes the **rich volume of existing national-level data** and builds upon peer-reviewed local studies and previous analyses that have investigated barriers to ANC engagement in Malawi. This methodological decision allows for **broad-scale geospatial analysis** and statistical modelling, providing a macro-level understanding of patterns in maternal health-seeking behaviour.

Antenatal care (ANC) is widely recognized as a critical point of entry into the formal health system—enabling early identification of obstetric risk factors and facilitating timely referral for delivery care. In this chapter, **Geographic Information Systems (GIS)** are used to map ANC coverage at the district level and to explore its spatial association with obstetric fistula prevalence, thereby illustrating how delays in the decision to seek care may contribute to long-term maternal morbidity.

The analysis reveals pronounced **geographic inequities**: while national ANC coverage remains low at **51%** for four or more visits, urban centres such as **Lilongwe** and **Blantyre** demonstrate relatively higher uptake. In contrast, districts such as **Mangochi**, **Machinga**, and **Chikwawa** are doubly burdened by **low ANC utilization and higher fistula prevalence**, suggesting compounded vulnerabilities in both prevention and timely access to skilled care.

Statistical correlation analysis indicates a **moderate inverse association** between ANC coverage and fistula prevalence (**$r = -0.68$, $p < 0.01$**), supporting the hypothesis that poor early engagement with antenatal services may be linked to higher maternal morbidity. These results

reflect systemic disparities in awareness, access, and trust in health services that contribute to Delay 1.

By framing ANC coverage as a measurable proxy for the First Delay, and by integrating GIS methods with national survey data, this chapter provides a **spatially informed, systems-level perspective** on maternal health-seeking behaviour. It complements existing qualitative findings from the Malawian context and avoids duplication of previously documented barriers, instead enhancing the empirical depth through spatial analytics and health systems framing.

This chapter lays the groundwork for **Chapter 6**, which addresses **Delay 2—the challenge of reaching care—through geographic accessibility modelling** of maternal and fistula repair services. Together, these thematic chapters build a comprehensive narrative of the layered delays that shape maternal health outcomes in Malawi.

5.1Draft manuscript for Paper 1

Geospatial Analysis of Antenatal Care Utilization and Obstetric Fistula in Malawi: Bridging Maternal Health Disparities

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(Submitted to BMC Surgery for Peer Review)

Abstract:

Background: Antenatal care (ANC) is a cornerstone of maternal health, enabling the early identification and prevention of complications. Despite global recommendations for at least four ANC visits, coverage in Malawi remains suboptimal, exacerbating maternal health disparities. Obstetric fistula, a severe and preventable childbirth injury, disproportionately affects women in underserved areas. This study leverages geospatial analysis to explore the relationship between ANC utilization, healthcare access, and fistula prevalence in Malawi, providing data-driven insights to inform interventions.

Methods: A population-based cross-sectional study was conducted using data from the 2015–16 Malawi Demographic and Health Survey (DHS), district-level population projections, and geocoded health facility datasets. Geographic Information Systems were employed to map

ANC utilization, health facility density, and fistula prevalence. Spatial autocorrelation, hotspot analyses, and regression modelling were used to identify patterns and relationships between ANC attendance, facility accessibility, and maternal health outcomes.

Results: The national prevalence of obstetric fistula was estimated at 0.6%, with regional variations (0.7% in the Northern and Southern regions, 0.4% in the Central region). High-risk districts, including Mangochi and Lilongwe Rural, reported an estimated 1,091 and 829 women with obstetric fistula, respectively. GIS mapping highlighted significant geographic disparities in healthcare access, particularly in rural districts like Mangochi, which has only 6.7 health facilities per 10,000 WRA, compared to urban centres like Lilongwe City (12.8 facilities per 10,000 WRA). ANC coverage was suboptimal, with only 51% of women attending four or more ANC visits during their pregnancy. A strong negative correlation was found between ANC coverage and obstetric fistula prevalence ($r = -0.68$, $p < 0.01$), indicating that districts with higher ANC coverage had lower rates of fistula. Barriers such as distance to health facilities (56% of women reported distance as a barrier) and financial constraints (53%) were significantly associated with higher fistula prevalence ($r = 0.53$, $p < 0.05$ and $r = 0.68$, $p < 0.01$, respectively).

Conclusion: Geographic disparities in maternal healthcare access are a key driver of obstetric fistula prevalence in Malawi. This study underscores the urgent need for equitable healthcare interventions in Malawi, particularly in rural areas. Expanding healthcare infrastructure, deploying mobile clinics, and addressing socioeconomic and cultural barriers are critical to improving ANC coverage and reducing fistula prevalence. While the findings are based on the most recent DHS data available (2015–16), the upcoming 2024–25 DHS presents a vital opportunity to assess progress and refine strategies. Future analyses incorporating updated data will be instrumental in monitoring and addressing persistent maternal health disparities.

Keywords: Antenatal Care, Obstetric Fistula, Geospatial Analysis, Maternal Health, Malawi, Healthcare Inequities, Spatial Epidemiology, Maternal Health Policy.

Introduction

Antenatal care is a cornerstone of maternal health, enabling early detection and prevention of complications during pregnancy. The World Health Organization (WHO) emphasizes ANC as critical to reducing perinatal morbidity and mortality, recommending a minimum of eight contacts during pregnancy to optimize maternal and fetal outcomes[1]. Despite the updated guidelines, ANC coverage remains suboptimal, particularly in low- and middle-income countries (LMICs), where structural, socioeconomic, and cultural barriers limit access to care[2,3].

Globally, maternal mortality remains a significant public health challenge. In 2020, approximately 287,000 maternal deaths were reported, with 70% occurring in sub-Saharan Africa—a region where maternal mortality ratios (MMRs) are among the highest in the world[3,4]. The lifetime risk of maternal death in LMICs is 1 in 49, compared to 1 in 5,300 in high-income countries[4]. Obstetric fistula, a preventable childbirth injury, epitomizes the health disparities, disproportionately affecting women in resource-constrained settings[5,6]. The condition results from obstructed labour, often exacerbated by delayed or inadequate ANC, leading to severe physical and psychosocial consequences. Obstructed labour, defined as the failure of fetal descent despite adequate uterine contractions, is the primary cause of obstetric fistula in LMICs. Effective intrapartum care—including partograph use, skilled supervision, timely cesarean delivery, and labour augmentation—is critical in preventing fistulas. WHO estimates that more than two million women live with untreated obstetric fistula globally, with sub-Saharan Africa bearing the largest burden[4,7–9]. Although data are limited, emerging evidence from Tanzania and elsewhere highlights iatrogenic causes—such as surgical trauma during cesarean delivery—as rising. In a systematic review by *Ngongo et al 2022).* In Malawi, the current burden of iatrogenic fistulas remains poorly documented and requires future research.

Regional studies highlight stark disparities in ANC utilization and maternal outcomes across sub-Saharan Africa. In Ethiopia, only 43% of women receive at least four ANC visits, with significant spatial disparities linked to rural residency, education, and socioeconomic status[10]. In Nigeria, despite efforts to improve maternal healthcare, only 57% of women attend at least one ANC visit, with rural regions reporting significantly lower attendance[11]. Similar trends are observed in Kenya and Tanzania, where geographic, financial, and infrastructural barriers hinder access to care, leaving many women without the recommended number of ANC

visits[12,13]. In Rwanda, although ANC utilization rates are relatively high, geospatial analyses reveal disparities between urban and rural areas, necessitating targeted interventions to address inequities.

Malawi, like many other countries in the region, faces persistent challenges in maternal health. While the maternal mortality ratio has declined from 1,100 deaths per 100,000 live births in 1990 to 381 in 2022, it remains among the highest globally. ANC coverage is suboptimal, with only 51% of women attending ANC4+ visits during their last pregnancy, according to the 2015–16 Malawi Demographic and Health Survey (DHS[14]). This limited ANC utilization is compounded by systemic barriers such as the uneven distribution of healthcare facilities, socioeconomic inequalities, and cultural factors. Obstetric fistula remains a pressing concern, with an estimated prevalence of 1 per 1,000 women of reproductive age, translating to thousands of untreated cases nationwide[15]. Malawi's rural districts exhibit higher rates of fistula and lower ANC attendance, underscoring the need for targeted interventions.

Geographic Information Systems and spatial analysis offer transformative potential for addressing maternal health disparities[16–22]. By mapping healthcare access and correlating it with maternal health outcomes, GIS provides actionable insights into regional disparities, enabling policymakers to allocate resources more effectively. While GIS has been utilized in several African countries to assess ANC coverage and healthcare access, there is a notable lack of studies that specifically examine the spatial distribution of obstetric fistula and its relationship with ANC utilization, particularly in Malawi. This knowledge gap limits the ability to design targeted interventions that address both immediate and systemic barriers to care.

This study employs GIS and spatial analysis to examine the spatial determinants of ANC utilization and obstetric fistula prevalence in Malawi. By integrating demographic, health facility, and geospatial data, the research aims to identify regions with critical healthcare gaps, providing evidence-based insights to guide policy and improve maternal health outcomes. Addressing the disparities is essential for achieving the Sustainable Development Goal of reducing global maternal mortality to fewer than 70 deaths per 100,000 live births by 2030[23] and ensuring equitable access to quality maternal healthcare services.

Methodology

Study Design and Data Sources

This population-based cross-sectional study utilized data from the 2015-16 Malawi Demographic and Health Survey, which employed a robust two-stage stratified sampling design, ensuring national representativeness. A total of 25,146 eligible women were identified, with a 97.7% response rate (24,564 interviews). Sampling weights were applied to adjust for selection probabilities and regional representation. Supplementary data sources included district-level population projections (2022-2023), the 2022 Malawi Master Health Facility List, and geospatial boundary files from the Malawi Spatial Data Platform and OpenStreetMap, enabling comprehensive mapping and demographic contextualization.

Estimation of Women of Reproductive Age (WRA)

Women aged 15–49 years were estimated to comprise 22% of the female population in sub-Saharan Africa from multiple DHS studies [24–26]. Using this proportion, district-level WRA populations were calculated from Malawi population projections. Sensitivity analyses (20–25%) were conducted to ensure robust demographic alignment with national profiles.

Obstetric Fistula Prevalence

Regional fistula estimated prevalence rates (0.7% in Northern and Southern regions; 0.4% in Central) from the DHS were applied to WRA estimates to determine district-level prevalence. Geospatial mapping in ArcGIS identified high-risk areas for targeted interventions.

Healthcare Access and Facility Distribution

Geocoded health facilities from the Master Health Facility List enabled spatial analysis of healthcare access. Facility density was calculated per 10,000 WRA per district. GIS proximity analysis determined average distances from residential zones to the nearest facilities, highlighting geographic barriers to maternal healthcare.

Analysis of ANC Coverage

ANC data were categorized into No ANC Visits, 1–3 Visits, and 4+ Visits. District-level coverage proportions were calculated from DHS data. Correlation and regression analyses assessed the relationship between ANC visits and fistula prevalence, quantifying the influence of ANC coverage on maternal health outcomes.

Spatial Analysis

GIS techniques integrated multiple datasets for spatial visualization and analysis:

- **Global Moran's I**: Measured spatial autocorrelation of ANC coverage and fistula prevalence.
- **Incremental Spatial Autocorrelation**: Identified clustering thresholds.
- Hotspot Analysis (Getis-Ord Gi): Highlighted districts with significant high or low fistula prevalence.
- **Ordinary Kriging Interpolation**: Predicted ANC coverage in unsampled areas.

Statistical Analysis

Data analysis in Stata 17 included descriptive statistics for key variables and Pearson's chi-square tests for associations. Correlation and regression analyses evaluated relationships between healthcare access, ANC coverage, and fistula prevalence. Multinomial logistic regression quantified maternal health outcomes, presenting relative risk ratios (RRR) with 95% confidence intervals.

Ethical Approval

Ethical clearance was obtained from the University of Cape Town Human Research Ethics Committee (Ref: 744/22) and the Lilongwe District Hospital Ethics Committee, with adherence to the Declaration of Helsinki and Malawi National Health Sciences Research Committee guidelines. MDHS data usage was authorized by MEASURE DHS.

Results

1. Estimation of Women of Reproductive Age (WRA)

In this study, the population of women aged 15–49 years (WRA) was estimated across Malawi's districts using the **2022–2023 population projections**. The national estimate for the total WRA population in **2023** is approximately **2.25 million**.

The **Southern** and **Central regions** exhibited the highest concentrations of WRA, with **Lilongwe Rural (207,320)** and **Mangochi (155,800)** as the most populous districts. The regions correspond to higher overall population densities and better access to urban centres.

Conversely, the **Northern region** showed smaller WRA populations, with **Likoma (1,754)** and **Chitipa (29,011)** districts reflecting the region's generally lower population density. The following table1, illustrates the estimated WRA for each district, calculated using the 22% proportion of women within the total female population. This district-level data is vital for understanding demographic distribution and informing interventions aimed at improving maternal health outcomes

Table 2: Summary Table: Estimated Women of Reproductive Age and Those with Obstetric Fistula by District

(The following table summarizes the findings across all districts, categorizing them by region)

Region	District	Total Female Population (2023)	Estimated Women Aged 15-49 (22%)	Estimated Women with Fistula	Fistula Percentage
Northern	Chitipa	131,871	29,011	203	0.7%
	Karonga	211,326	46,492	325	0.7%
	Nkhata Bay	158,828	34,942	245	0.7%
	Rumphi	130,205	28,645	201	0.7%
	Mzimba	527,389	116,026	812	0.7%
	Mzuzu City	140,837	30,984	217	0.7%
	Likoma	7,973	1,754	12	0.7%
Central	Kasungu	480,470	105,703	423	0.4%
	Nkhota Kota	223,489	49,167	197	0.4%
	Ntchisi	187,323	41,211	165	0.4%
	Dowa	448,703	98,715	395	0.4%
	Salima	283,981	62,476	250	0.4%
	Lilongwe Rural	942,366	207,320	829	0.4%
	Lilongwe City	582,127	128,068	512	0.4%
	Mchinji	342,377	75,323	301	0.4%
	Dedza	485,189	106,742	427	0.4%
	Ntcheu	386,876	85,112	340	0.4%
Southern	Mangochi	708,179	155,800	1,091	0.7%
	Machinga	457,922	100,743	705	0.7%
	Zomba Rural	433,024	95,265	667	0.7%
	Zomba City	59,726	13,140	92	0.7%
	Chiradzulu	203,383	44,744	313	0.7%
	Blantyre Rural	262,160	57,675	404	0.7%

	Blantyre City	436,325	95,991	672	0.7%
	Mwanza	78,106	17,184	120	0.7%
	Thyolo	413,382	90,944	636	0.7%
	Mulanje	399,493	87,889	615	0.7%
	Phalombe	252,100	55,462	388	0.7%
	Chikwawa	321,765	70,788	495	0.7%
	Nsanje	171,428	37,714	264	0.7%
	Balaka	263,641	57,961	406	0.7%
	Neno	78,282	17,222	121	0.7%

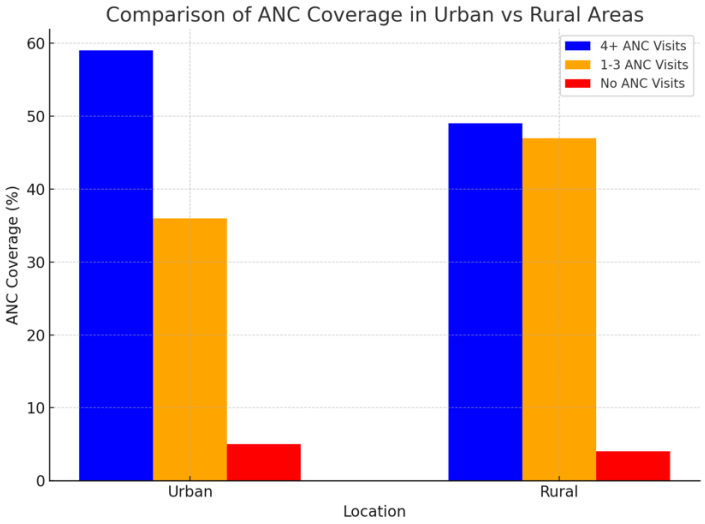
2. Antenatal Care (ANC) Coverage

The study assessed the coverage of antenatal care (ANC) across districts, which is a critical determinant of maternal health. **Nationwide, only 51% of women** completed the recommended four or more ANC visits during their most recent pregnancy. However, significant differences were observed between urban and rural areas:

- In **urban areas**, ANC coverage is notably higher, with **59% of women** attending four or more ANC visits.
- In **rural areas**, **49% of women** completed the recommended visits, but the remaining women typically attended **1–3 ANC visits (47%)** or did not attend any ANC visits at all (**4%**) (see figure 1).

This disparity suggests a more robust healthcare infrastructure in urban areas, which likely facilitates higher ANC uptake, while rural areas face significant barriers such as limited healthcare access, distance, and socioeconomic constraints.

Figure 8: Bar Graph Comparing ANC Coverage in Urban vs. Rural Areas



This bar chart clearly contrasts ANC coverage between urban and rural settings, showcasing the higher percentages of women completing four or more ANC visits in urban areas. The visual underscores the need for increased outreach and healthcare services in rural regions to ensure equitable access to maternal care.

3. Estimation of Obstetric Fistula Prevalence

Using regional prevalence rates from the 2015–16 DHS, the national prevalence of obstetric fistula was estimated at 0.6%, translating to approximately 13,842 women affected across Malawi. The Southern and Northern regions showed the highest prevalence, with Mangochi (1,091 cases), Lilongwe Rural (829 cases), and Blantyre City (672 cases) contributing the largest estimated case numbers. While these figures highlight areas of higher burden, interpretation requires caution, as urban centres such as Lilongwe and Blantyre host fistula repair facilities. Consequently, patient relocation or care-seeking migration from surrounding districts may inflate prevalence estimates for these cities relative to their resident populations. Notably, regions reporting higher prevalence also tend to exhibit lower antenatal care (ANC) coverage and reduced health facility density, compounding barriers to prevention and timely treatment.

This table provides an overview of fistula prevalence rates by region, emphasizing the greater burden in the Southern and Northern regions. The data aligns with the regional disparities in healthcare access and ANC coverage.

*Table 3**: Obstetric Fistula Prevalence by Region**.*

Region	Estimated WRA	Prevalence Rate	Estimated Women with Fistula
Northern	287,854	0.7%	2,015
Central	959,837	0.4%	3,839
Southern	1,000,522	0.7%	7,988
Total	**2,248,213**	**0.6%**	**13,842**

4. Distribution and Accessibility of Health Facilities

Healthcare facility distribution was assessed to understand how access to maternal healthcare correlates with fistula prevalence. Urban centres such as Lilongwe City (12.8 facilities per 10,000 WRA) and Blantyre City (11.2 facilities per 10,000 WRA) reported higher facility densities, which likely contribute to better access to maternal healthcare services. In contrast, rural districts like Mangochi (6.7 facilities per 10,000 WRA) and Machinga (5.8 facilities per 10,000 WRA**)** reported fewer healthcare facilities, leading to significant barriers to care and higher obstetric fistula prevalence. See Table **(**This table highlights the relationship between the number of healthcare facilities and obstetric fistula prevalence, illustrating how low facility density may reduce access to antenatal care predisposing the risk of higher fistula rates).

5. Barriers to Healthcare Access

A significant portion of women reported facing barriers to healthcare access (DHS):

- 56% of women reported that distance to healthcare facilities was a major challenge, especially in rural districts.
- 53% of women cited financial constraints as a limiting factor, with low-income groups facing the most severe impacts.
- Social and cultural barriers also played a role, with 30% of women reluctant to attend healthcare facilities alone and 16% facing difficulty in obtaining permission to seek care.

Districts such as **Mangochi** and **Dowa**, where the barriers are more pronounced, also exhibit higher rates of fistula prevalence. This underscores the need for infrastructure development and social interventions to address the barriers.

Figure 9: Map of Health Facility Distribution.

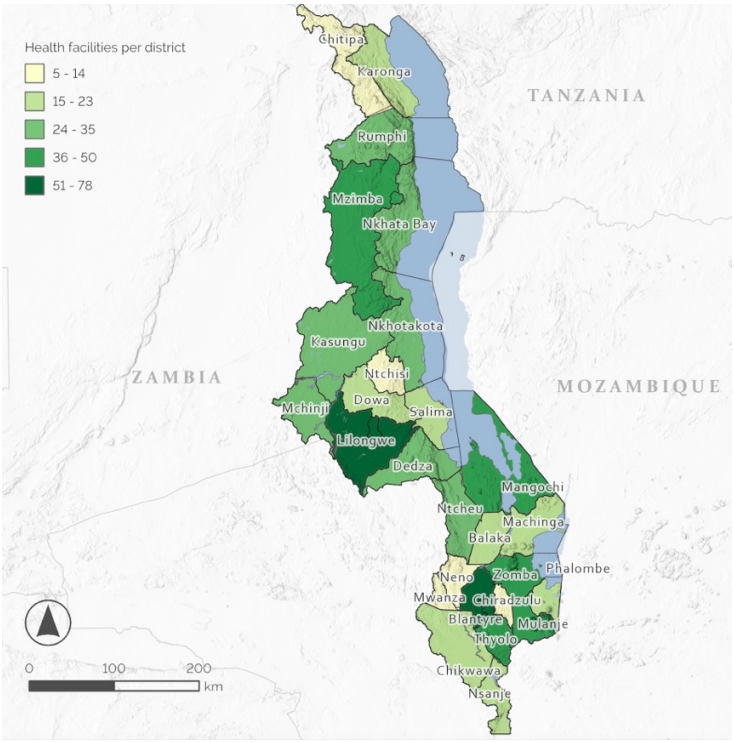


*Figure 10**(a and b):** A **GIS map** highlighting the geographic distribution of obstetric fistula prevalence across Malawi's districts.* This map provides a visual representation of where fistula cases are concentrated and the health facility density as per fistulae repair database.

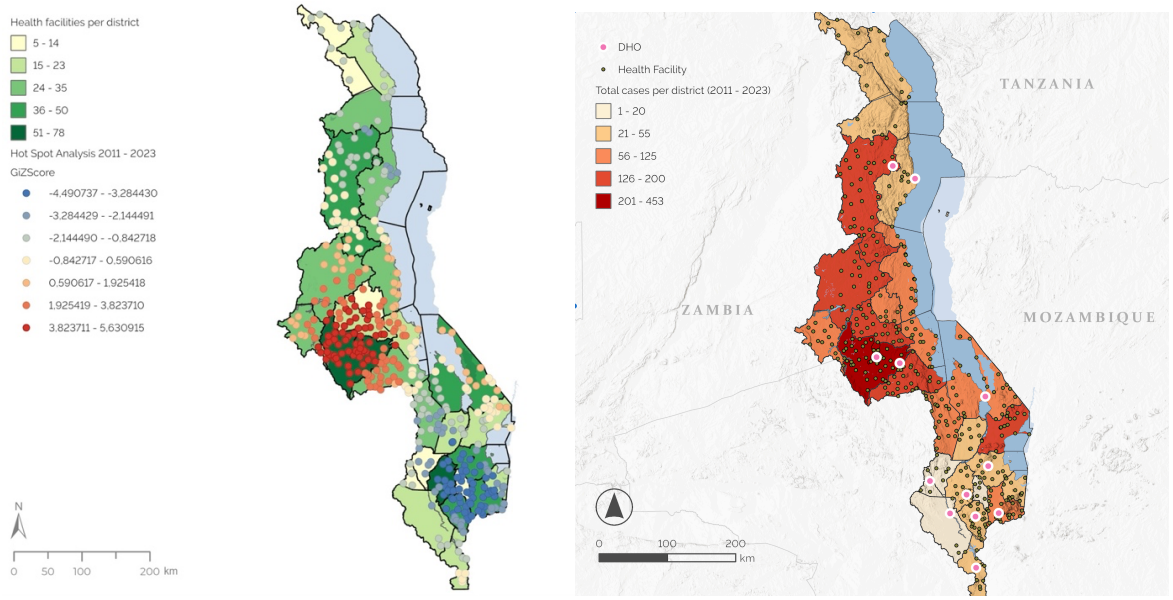
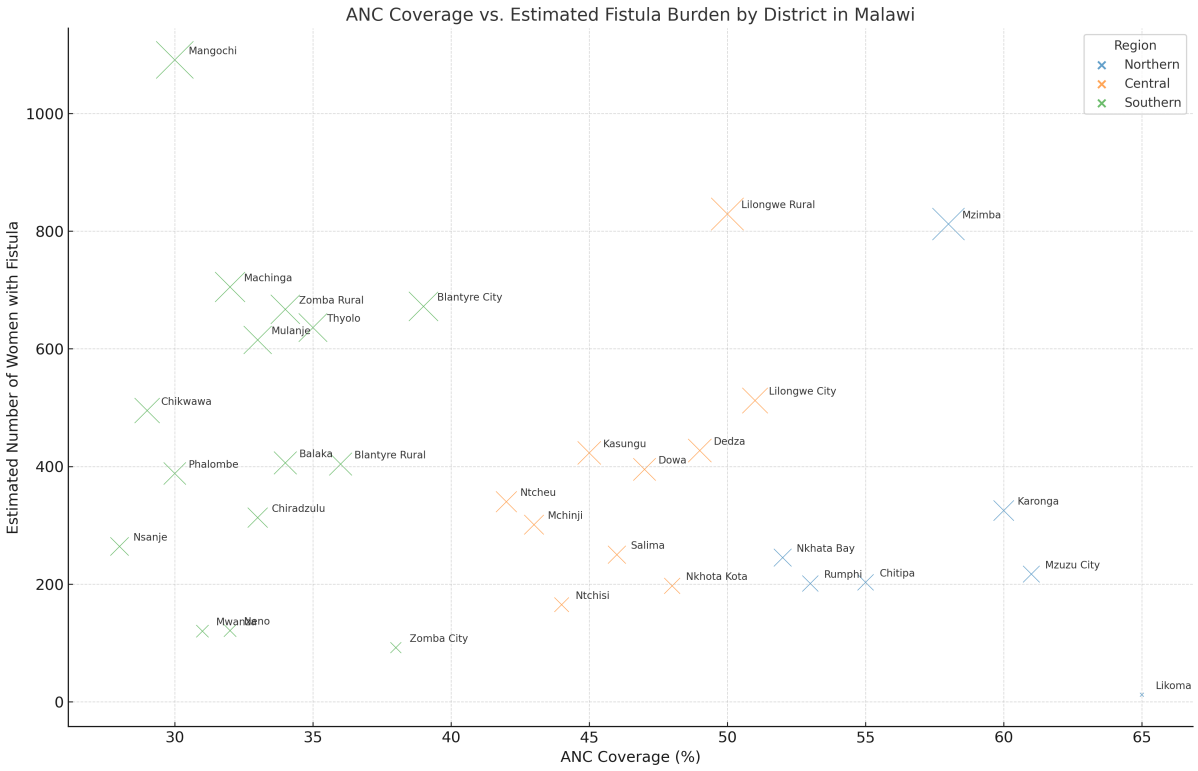


Figure 11. ***Bubble chart showing relationship of ANC4+ and estimated fistula cases per district.***



This figure 11 above presents the relationship between ANC4+ coverage and estimated obstetric fistula burden across Malawi's 28 districts, using regional colour coding and marker size to reflect burden magnitude. While a general inverse trend is observable—districts with lower ANC coverage such as Mangochi, Machinga, Chikwawa, and Nsanje show higher estimated fistula burden—this relationship is not uniformly linear. Notably, high-burden recorded in some areas such as Lilongwe Rural and Lilongwe City may reflect referral patterns to Bwaila Fistula Centre rather than local incidence alone, as patients from remote districts often list city addresses. These findings support the need for geographically nuanced interventions but should be interpreted within the limitations of facility-based repair data and spatial attribution. (Mzimba was also an outlier needs further exploration since its one of the biggest districts, with sparsely spread population, while Likoma being small island means the population can access health facility within a short time). Blantyre as another regional fistula centre shares the same relocation effect and adds to the attribute of local address case.

These patterns underscore the need for geographically targeted interventions: strengthening gains in the North, addressing persistent rural gaps in the Central region, and prioritizing health system improvements in the Southern region where multiple vulnerabilities converge. (The

elevated fistula prevalence in Lilongwe may reflect referral concentration at tertiary centers rather than true community-level incidence.)

While Figure 11 suggests potential spatial clustering of maternal health indicators, these visual trends do not establish causal relationships between access variables and clinical outcomes. Further multivariate regression analyses would be required to quantify and confirm such associations.

5. Correlation Between ANC Coverage, Facility Density, and Fistula Prevalence

Statistical analysis demonstrated significant associations between maternal health service indicators and obstetric fistula prevalence at the district level. The proportion of women attending four or more ANC visits was strongly and inversely correlated with fistula prevalence ($r = –0.68$, $p < 0.01$), suggesting that higher ANC coverage is associated with reduced fistula burden. Similarly, health facility density showed a significant negative correlation ($r = –0.62$, $p < 0.01$), indicating that districts with greater healthcare infrastructure tend to report lower fistula prevalence. Conversely, mean distance to the nearest healthcare facility exhibited a positive correlation ($r = 0.53$, $p < 0.05$), underscoring the potential role of geographic barriers in exacerbating adverse maternal outcomes. While these relationships highlight important spatial and health system patterns, they should be interpreted with caution as they reflect correlations rather than causality, and may be influenced by confounding factors such as population mobility, referral patterns, and data limitations.

*Table 4**: Correlation Analysis Summary***

Variable 1	**Variable 2**	**Correlation Coefficient (r)**	**p-value**
Facility Density	Fistula Prevalence	-0.62	< 0.01
4+ ANC Visits (%)	Fistula Prevalence	-0.68	< 0.01
Distance to Health Facility	Fistula Prevalence	0.53	< 0.05

Discussion

Maternal and child mortality remain critical public health challenges, particularly in low- and middle-income countries (LMICs), where complications during pregnancy and childbirth are among the leading causes of death. WHO recommends at least eight antenatal care (ANC8+) visits as a core strategy to safeguard maternal health [1] .

The study's main highlights showed that Malawi's estimated Women of Reproductive Age (WRA) population in 2023 was approximately 2.25 million. Healthcare facility density is higher in urban districts like Lilongwe and Blantyre (12.8 and 11.2 facilities per 10,000 WRA, respectively), but the centres remain congested due to large populations. In contrast, rural areas such as Mangochi and Machinga exhibit significantly lower facility density (6.7 and 5.8 per 10,000 WRA, respectively), compounded by long travel distances and limited infrastructure. Only 51% of women nationwide completed four or more ANC visits, with rural areas (49%) lagging urban areas (59%). The prevalence of obstetric fistula, estimated at 0.6% (13,842 cases), is highest in districts with low facility density and ANC coverage, such as Mangochi (1,091 cases) and Lilongwe Rural (829 cases). Statistical analysis reveals strong negative correlations between ANC coverage and fistula prevalence ($r = -0.68$, $p < 0.01$) and between facility density and fistula prevalence ($r = -0.62$, $p < 0.01$). Conversely, distance to healthcare facilities correlates positively with fistula prevalence ($r = 0.53$, $p < 0.05$), emphasizing the role of geographic barriers in limiting access to maternal healthcare. This highlights a potential relationship between ANC access and fistula burden, but causal inference cannot be drawn from cross-sectional spatial data.

The disparities observed in maternal health outcomes in Malawi mirror broader patterns across Sub-Saharan Africa (SSA). A 2016 study by Yaya et al identified wealth inequality, education, and rural residence as significant predictors of maternal healthcare utilization in Malawi [27]. Women in rural areas and those with lower educational attainment consistently had lower ANC attendance and postnatal care utilization. Similar findings have been reported in Ethiopia and Uganda, where economic disparities and education gaps strongly influence healthcare-seeking behaviour[28–30].

Geospatial insights provide further clarity on the issues. A 2024 study by Mwenebanda et al. focused on GIS-enabled analysis of ANC attendance in Blantyre, Malawi, and emphasized that geographic accessibility—including proximity to healthcare facilities—is a critical determinant of service utilization[31]. Nepal's expansion of rural birthing centres offers a relevant parallel, where improved geographic access increased facility-based deliveries from 18% in 2006 to 59% in 2016[32]. The findings reinforce the importance of targeted, geographically-informed interventions in Malawi's underserved regions.

Robust evidence underscores the protective role of ANC in reducing maternal and neonatal complications. A 2024 study by Fenta et al, found that adequate ANC utilization is significantly associated with improved maternal outcomes across SSA[33]. However, Malawi's ANC coverage of 51% for four or more visits lags the SSA average of 58%, with countries like Rwanda achieving 69% coverage through innovative community health worker programs[34,35]. "Several districts with lower ANC4+ coverage also exhibited higher modelled fistula prevalence; however, this observation warrants cautious interpretation due to potential confounding."

In Uganda, women attending at least four ANC visits were 12% more likely to deliver in healthcare facilities and had higher rates of early postnatal care[36]. This evidence highlights the critical importance of comprehensive ANC in preventing complications, improving intrapartum care and linkage to postpartum followup.

Barriers to ANC utilization in Malawi are multifaceted[37,38]. Social-cultural factors, such as not wanting to go alone and needing permission to visit a doctor, were reported by 30% and 16% of women, respectively[39]. The barriers are often linked to traditional gender norms and can delay access to care, particularly in rural and conservative communities. Financial constraints, cited by 53% of women, disproportionately affect rural populations, limiting their ability to access care. There is a positive correlation between financial constraints and the prevalence of obstetric fistula ($r = 0.68$, $p < 0.01$). This finding suggests that economic barriers significantly impact women's ability to access necessary maternal health services, increasing the risk of complications. Conditional cash transfer programs, such as India's Janani Suraksha Yojana, have been effective in addressing the barriers by incentivizing ANC attendance and institutional deliveries[40–44].

This study's findings—that healthcare facility density correlates negatively with fistula prevalence—align with counter-evidence from Botswana and South Africa, where higher facility availability is associated with reduced maternal morbidity and mortality[45–47]. However, Malawi's rural districts remain underserved, with limited emergency obstetric care capacity. A 2023 study by Riches et al. reported high maternal mortality rates following cesarean sections in Malawi due to delays in treatment and lack of blood transfusion services, highlighting critical gaps in emergency care infrastructure[48].

GIS-based analyses offer actionable solutions by identifying hotspots of maternal health disparities. For example, this study's hotspot analysis revealed districts like Mangochi and

Dowa as high-burden areas with both low facility density and low ANC coverage. Interventions informed by geospatial data—such as strategically locating new facilities or deploying mobile clinics—can optimize resource allocation and improve healthcare access in the regions.

Strengths and limitations

This study effectively uses GIS to identify spatial disparities in maternal health services, integrating data on ANC coverage, healthcare facility density, and obstetric fistula prevalence. This comprehensive approach enables targeted policy responses and aligns findings with broader regional and global maternal health challenges.

However, reliance on secondary data may not reflect recent trends, and district-level analysis can mask local variations. Uniform prevalence estimates for obstetric fistula may oversimplify regional differences. The GIS data on ANC coverage and healthcare access in Malawi highlights associations but cannot establish causal links to obstetric fistula prevalence without considering other critical factors such as socioeconomic status, cultural practices, transportation barriers, and emergency obstetric care quality.

Addressing the challenges requires expanding healthcare infrastructure in underserved areas like Mangochi and Machinga and introducing mobile clinics and community outreach programs. The Safe Motherhood Initiative's focus on engaging communities and leaders to support ANC attendance serves as a valuable model. Financial incentives, such as conditional cash transfers modelled on "India's Janani Suraksha Yojana", could boost ANC utilization and facility-based deliveries. Strengthening emergency obstetric care and training healthcare providers to manage complications are also critical. Future research should include localized and longitudinal studies to deepen insights and refine interventions.

Conclusion

This study underscores the need for equitable maternal healthcare in Malawi, particularly in rural districts with limited access. Targeted GIS-driven interventions, community-focused initiatives, and investments in healthcare systems are essential. Lessons from global best practices and the Safe Motherhood Initiative offer scalable solutions to improve outcomes for women and children, advancing Malawi's progress toward sustainable maternal health

improvements. “These geospatial results should be viewed as exploratory and hypothesis-generating, warranting further epidemiological and systems-level investigation.”

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CHAPTER 6: GEOSPATIAL INEQUITIES IN ACCESS TO FISTULA REPAIR – EXPLORING DELAY 2

6.1 Overview of the Chapter

Following the analysis of Delay 1 (the decision to seek care) through antenatal care coverage in Chapter 5, this chapter now shifts focus to **Delay 2**—the challenge of **reaching appropriate maternal care**. Using obstetric fistula as a tracer condition, this chapter assesses the geographic accessibility and equity of fistula repair services across Malawi, highlighting how spatial and systemic barriers disproportionately affect rural and underserved populations.

Despite being a surgically treatable condition, obstetric fistula continues to burden women in remote areas due to the **concentration of repair services in urban hubs**—particularly Lilongwe and Blantyre—which together account for approximately **80% of all repairs** nationally. In contrast, high-prevalence rural districts such as **Mangochi, Machinga, and Chikwawa** face critical service deficits, despite reporting fistula rates exceeding the national average of **0.6%**.

Using Geographic Information Systems (GIS), the chapter applies **travel-time modelling** and spatial accessibility analyses to quantify barriers to care. Findings reveal that women in many rural districts face travel times exceeding **three to five hours**, contributing to **delayed presentations** and **more complex cases**. These findings reinforce the need for **decentralized service delivery**, including **mobile clinics** and **satellite repair units**, to address the spatial misalignment between need and service availability.

GIS-based equity metrics such as the **Lorenz curve** and **Gini coefficient (0.68)** confirm a highly unequal distribution of services, with most fistula repairs concentrated in just **20% of districts**. This spatial inequality mirrors deeper systemic issues in resource allocation and healthcare planning. The identification of high-need, low-access zones—particularly in the Southern Region—presents a compelling opportunity for targeted policy and investment.

This chapter builds methodically from the Delay 1 analysis and lays the groundwork for the upcoming chapter on Delay 3 (receiving quality care), where the **outcomes of fistula surgery** are examined. Together, these insights form an integrated understanding of the barriers women face across the continuum of care.

Ultimately, this chapter argues for a **recalibration of maternal health service distribution** in Malawi, rooted in empirical geospatial evidence. By addressing geographic barriers and improving accessibility to fistula repair services, the study aligns with broader health system goals and **Sustainable Development Goal 3**—ensuring equitable access to essential health service.

6.1 Draft manuscript for Paper 2

Geospatial Analysis of Obstetric Fistula Prevalence and Repair Services in Malawi: Evaluating Healthcare Access, Equity, and Efficiency in Maternal Health Outcomes.

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Submitted to the BMC Global and Public Health for Peer Review

Geospatial Analysis of Surgical Access for Obstetric Fistula Repair in Malawi: Addressing Inequities in Maternal Surgical Care

Abstract

Background: Obstetric fistula remains a significant maternal health burden in Malawi, affecting 1.6 per 1,000 women of reproductive age, with an estimated 13,000–20,000 women currently living with the condition. Despite commitments to eliminating fistula by 2030, disparities in surgical access, workforce shortages, and geographic barriers persist. The condition, resulting from obstructed labour without timely intervention, leads to chronic incontinence, stigma, and morbidity. While Malawi's National Surgical, Obstetric, and Anaesthesia Plan (NSOAP) aims to strengthen maternal surgical care, inequities remain. This study employs Geographic Information Systems (GIS) and national epidemiological data to assess surgical service distribution and accessibility to inform policy and intervention strategies.

Methods: A mixed-methods approach was used, integrating data from the 2015–16 and 2024 Malawi Demographic and Health Surveys (MDHS), the 2019–20 and Malawi Multiple Indicator Cluster Survey (MICS). GIS-based spatial analyses mapped fistula repair facilities, estimated travel times, and identified high-risk areas. While regression models examined

associations between Antenatal-Care (ANC)coverage, fistula prevalence, and geographic access.

Results: Obstetric fistula remains concentrated in rural districts with the lowest ANC coverage and greatest travel-time barriers. The Gini coefficient of 0.68 highlights severe disparities, with over 80% of repairs occurring in just 20% of districts. Services remain highly centralized, with most procedures conducted in urban referral centres, leaving high-burden rural districts underserved. Malawi has less than 10 fistula surgeons, predominantly based in urban facilities despite 77 trained over 10 years. The two urban facilities perform just over 400 repairs annually, covering 85% of national cases despite limited trained surgeons. With minimal capacity elsewhere, backlog elimination remains unfeasible, prolonging median delays of 7.2 years and worsening surgical complexity and social impact. GIS analysis identified high-risk zones with travel times exceeding four hours, reinforcing geographic barriers to timely intervention.

Conclusion: Persistent inequities necessitate decentralizing fistula repair services, expanding the surgical workforce, and leveraging GIS for strategic planning. Aligning NSOAP implementation with Global Surgery 2030 through task-shifting, regional access expansion, and equitable workforce distribution is essential. Without targeted investment, elimination by 2030 remains unattainable, requiring a revised long-term strategy beyond 2050.

Keywords: Obstetric fistula, Geospatial analysis, Maternal health, Healthcare access, Antenatal care, Malawi, Health equity, GIS, Rural health disparities, Surgical services distribution.

Introduction

Obstetric fistula remains a critical global health challenge, disproportionately affecting women in low-resource settings[1,2]. With an estimated two million women living with fistula globally and 50,000–100,000 new cases annually, this devastating childbirth injury is most prevalent in sub-Saharan Africa and South Asia[2–4]. Obstructed labour without timely emergency obstetric care is the primary cause, resulting in chronic incontinence, social stigma, and psychological trauma[5]. In Malawi, a country with a population of over 20 million[6], maternal health outcomes reflect these systemic challenges. The maternal mortality ratio (MMR) is 381 deaths per 100,000 live births[7], significantly above the Sustainable Development Goal (SDG) target of fewer than 70 by 2030[8].

Access to timely institutional deliveries and quality emergency obstetric care is critical for reducing maternal complications, including fistula[2]. While Malawi's institutional delivery rates have improved from 35.2% in 2014 to 51.7% in 2023, rural areas still lag urban centres where healthcare services are concentrated. The cesarean section (C-section) rate remains critically low at 6%, far below the WHO-recommended 10%-15% necessary to manage obstetric complications[9]. These gaps exacerbate the burden of obstetric fistula, with national prevalence at 1.6 cases per 1,000 women and higher rates of 0.7% in districts such as Mangochi and Machinga, which face significant barriers to care[10].

Antenatal care (ANC) is a cornerstone of maternal health, yet Malawi's ANC4+ coverage—defined as at least four antenatal visits during pregnancy—ranges from 26.6% to 61%[9], far below the global target of 70% set by the Ending Preventable Maternal Mortality (EPMM) strategy for 2025[11,12]. Early ANC initiation is also low, with only 12%-15% of women attending their first visit during the first trimester[9]. These delays hinder early detection and management of pregnancy complications, particularly in rural districts where healthcare resources and skilled personnel are scarce.

Malawi's healthcare infrastructure further limits maternal health outcomes. The country averages only 7 hospital beds per 10,000 population, far below the WHO recommendation of 25[13]. The healthcare worker density is similarly inadequate, with 10.42 core health workers per 10,000 people—meeting just 45% of the global threshold for universal health coverage. Physician density is as low as 0.2 per 10,000, and the nurse-to-patient ratio is 1:2,300, far exceeding international recommendations[9]. These shortages are more pronounced in rural areas, where 86.5% of the population resides and access to maternal healthcare is most limited[6].

Malawi's Vision 2063 prioritizes equitable healthcare access, aiming to reduce maternal mortality and enhance the quality of care. Geographic Information Systems (GIS) have emerged as a vital tool in addressing these challenges by mapping healthcare inequities and guiding resource allocation[14–20]. Geographic access to healthcare is a critical determinant of maternal health outcomes. Evidence shows that maternal mortality rates increase with distance from healthcare facilities, rising from 111 deaths per 100,000 live births for women living within 5 km of a facility to 422 deaths per 100,000 for those beyond 35 km[21].In Malawi, the concentration of healthcare infrastructure in urban hubs, combined with poor road networks and high transportation costs, exacerbates delays in accessing care, particularly in emergencies. These insights inform targeted interventions, aligning with SDG targets and national strategies.

This study evaluates the geographic distribution of obstetric fistula prevalence and repair services in Malawi, hypothesizing that services are disproportionately concentrated in urban areas, disadvantaging rural populations. It also examines the relationship between ANC coverage and fistula prevalence, using data from the 2015–2016 Demographic and Health Survey (DHS) and 2019–2020 Multiple Indicator Cluster Survey (MICS). As Malawi prepares for the 2024 DHS, this research sets a critical baseline for addressing inequities and achieving sustainable improvements in maternal health outcomes.

Methodology

Study Design

This study employed a mixed methodology design integrating geospatial analysis, epidemiological modelling, health equity assessments, and health facility database reviews to evaluate disparities in maternal surgical care, particularly obstetric fistula prevalence and access to repair services across Malawi's 28 districts. A mixed-methods approach was applied to synthesize nationally representative household survey data, Geographic Information Systems (GIS) analysis, travel time estimations, and health facility-level data, ensuring scientific rigor, replicability, and policy relevance.

Study Setting and Population

Malawi, a landlocked country in south-eastern Africa, shares borders with Zambia, Tanzania, and Mozambique. Administratively, it is divided into 28 districts across three regions: Northern, Central, and Southern. The economy is predominantly agrarian, with over 80% of the population engaged in subsistence farming, making it highly vulnerable to climate-related shocks. Malawi remains one of the world's poorest countries, with approximately 70% of the population living on less than USD 2.15 per day[22]. The healthcare system faces structural and financial challenges, with limited workforce capacity, constrained infrastructure, and high disease burdens affecting access to maternal and emergency surgical care.

With an estimated population of 20.5 million in 2024[23], Women of Reproductive Age (WRA) (15–49 years) constitute approximately 5.1 million, representing 24.8% of the total population. Obstetric fistula repair services in Malawi are highly centralized, with 12 designated repair centres—but only nine functionally active, disproportionately located in urban hubs (Lilongwe and Blantyre). This study specifically analysed geographic disparities in surgical access,

evaluating variables including travel time to fistula repair centres, antenatal care (ANC) coverage, surgical workforce distribution, and health facility density.

Mixed-Methods Framework

To comprehensively assess disparities in obstetric fistula care, the study applied a mixed-methods approach combining quantitative, geospatial, and policy analysis techniques. The following table 1 below summarizes the methodology used.

Table 5 Outline of the mixed methodology

Methodology Component	Data Source	Analytical Tool	Outcome Measured
Demographic Analysis	2024 & 2015–16 MDHS, 2019–20 MICS	Stata v17.0, SPSS v27	Fistula prevalence, ANC coverage, WRA estimates
Geospatial Mapping	MASDAP, OpenStreetMap, Malawi Master Health Facility List	ArcGIS Pro v3.1,	Distribution of fistula repair centres, travel times
Equity Analysis	MDHS, Health Facility Data	Statistica v14.0	Lorenz Curve, Gini Coefficient
Statistical Modeling	MDHS, MICS	Stata v17.0	Multivariate regression on ANC and fistula prevalence
Surgical Workforce Assessment	National Obstetric Fistula Strategic Plan 2023–2030	Descriptive analysis	Active vs. inactive fistula surgeons
Health Facility Distribution	Bwaila Fistula Centre records	Facility data review	Surgical capacity, repair volume

Data Sources and Sampling Framework

1. **Malawi Demographic and Health Survey (MDHS)**

The Malawi Demographic and Health Survey (MDHS) is a nationally representative household survey that has been conducted six times: in 1992, 2000, 2004, 2010, 2015–16, and 2024. It

provides comprehensive data on mortality, morbidity, healthcare utilization, and population-based health indicators.

The 2024 MDHS, implemented by the National Statistical Office (NSO) of Malawi in collaboration with the Ministry of Health (MoH), Public Health Institute of Malawi (PHIM), and development partners, followed a stratified two-stage cluster sampling design to ensure national representation. The survey sampled 23,070 households across 769 enumeration areas (EAs), yielding a 96% response rate, with 20,849 women (15–49 years) and 8,583 men (15–54 years) successfully interviewed.

For comparison, the 2015–16 MDHS involved 27,516 households across 850 EAs, with 24,562 women (15–49 years) and 7,478 men (15–54 years) interviewed, allowing for longitudinal analysis of health trends. The EAs were selected using probability proportional to size (PPS) sampling, with urban and rural strata ensuring district-level representation. A household listing and mapping exercise preceded data collection, enabling accurate frame updating. The MDHS dataset is accessible online through the MEASURE DHS website https://dhsprogram.com.

2. **Malawi Multiple Indicator Cluster Survey (MICS) 2019–20**

The MICS dataset, conducted by UNICEF in collaboration with the Government of Malawi, supplemented DHS data by providing district-level maternal and child health indicators, including timing of ANC visits, birth preparedness, and surgical workforce shortages. Sampling covered 26,000 households, with a response rate exceeding 95%, ensuring robust estimates for policy interventions. Data from the survey are freely accessible via UNICEF at https://mics.unicef.org.

3. **National Obstetric Fistula Strategic Plan (2023–2030)**

The strategic plan provided detailed insights into fistula prevalence, surgical workforce distribution, and repair capacity across Malawi's fistula repair centres. Since the establishment of Bwaila Fistula Centre in 2012, 77 fistula surgeons have been trained, yet only three remain actively performing repairs. Most trained providers examine and refer patients rather than conducting surgeries, leading to reliance on periodic fistula repair camps to supplement routine services.

Geographic Information Systems (GIS) and Health Facility Data

Geospatial data, including district boundaries, road networks, and healthcare facility locations, were sourced from, Malawi Spatial Data Platform (MASDAP), OpenStreetMap,2022 Malawi Master Health Facility List (World Bank) and Fistula repair case data from Bwaila Fistula Centre (access obtained with permission).

Geospatial Accessibility Modelling Framework

To quantify fistula repair access, the study integrates Kernel Density Estimation (KDE), friction surface modelling, and Gini coefficient analysis**,** which allow for a comprehensive understanding of the accessibility landscape.

Kernel Density Estimation (KDE)

Kernel Density Estimation (KDE) is a non-parametric way of estimating the probability density function of a random variable. In this study, KDE is applied to assess the spatial concentration of fistula repair services and to identify areas where services are insufficient relative to need.

The KDE function is defined as:

$$K(x) = \sum_{i=1}^{n} \frac{1}{h^2} K\left(\frac{||x - x_i||}{h}\right)$$

where:

- K is the Gaussian kernel function,
- x_i represents the location of fistula repair facilities,
- h is the bandwidth parameter.

Areas with low KDE values represent underserved regions where service expansion is necessary.

Friction Surface Modelling

Friction surface modelling is used to estimate travel time to the nearest fistula repair facility by accounting for different transportation modes and geographic barriers such as terrain elevation and road network quality. ("The travel times were modelled assuming a **motorized transport** (e.g., ambulance or vehicle) on the road network. We also acknowledge that this is a simplification – in reality some women may travel by foot or ox-cart, which would take longer – but for the analysis we assumed motorized transport as a proxy for an ideal scenario of ambulance transport"). The model computes travel time as follows:

The travel time function (T_A) is defined as:

$$T_A = \left(\frac{D_i}{S_m} \right) \times W_c$$

where:

- D_i represents the distance to the nearest repair centre,
- S_m is the mode-specific travel speed (walking, bicycle, motor vehicle),
- W_c is a weighted correction for road conditions and accessibility constraints.

This method helps identify areas where transport infrastructure improvements or mobile surgical outreach programs are necessary to enhance service delivery. (This technique was recommended but not calculated in our study, we adopted findings from Palk et al 2000)[24]

Gini Coefficient for Equity Assessment

The Gini coefficient is a measure of inequality that quantifies the disparities in access to fistula repair services across Malawi's urban and rural populations. It is calculated as:

$$G = 1 - \sum_{i=1}^{n} (X_i + X_{i-1}) \times (Y_i - Y_{i-1})$$

where:

- X_i is the cumulative percentage of the population,
- Y_i is the cumulative percentage of healthcare access.

where represents the cumulative percentage of the population and represents the cumulative percentage of healthcare access. Interpretation of Gini Coefficients:

- **G = 0.00 - 0.20 → Minimal Inequality** (Access is evenly distributed)
- **G = 0.21 - 0.40 → Moderate Inequality**
- **G = 0.41 - 0.60 → High Inequality**
- **G > 0.60 → Severe Inequality** (Access is highly skewed toward urban areas)

Analytical Methods

Geographic Information Systems (GIS) were utilized to map healthcare facilities providing fistula repair services, employing kernel density interpolation to visualize facility concentrations and travel time analysis to estimate accessibility, considering transportation modes and road quality. Hotspot analysis using the Getis-Ord Gi* statistic identified clusters of high fistula prevalence, low antenatal care (ANC) coverage, and limited repair services. Descriptive statistics summarized maternal health indicators, including ANC coverage, fistula prevalence, and institutional delivery rates. Pearson correlation coefficients quantified relationships between fistula prevalence, ANC coverage, and healthcare access. A multivariate regression model assessed the association between fistula prevalence and predictors such as ANC coverage, population density, and geographic proximity to healthcare facilities. Equity analysis involved calculating the Gini coefficient and plotting Lorenz curves to quantify disparities in the distribution of fistula repair services relative to the women of reproductive age population, highlighting geographic inequities.

Ethical Considerations

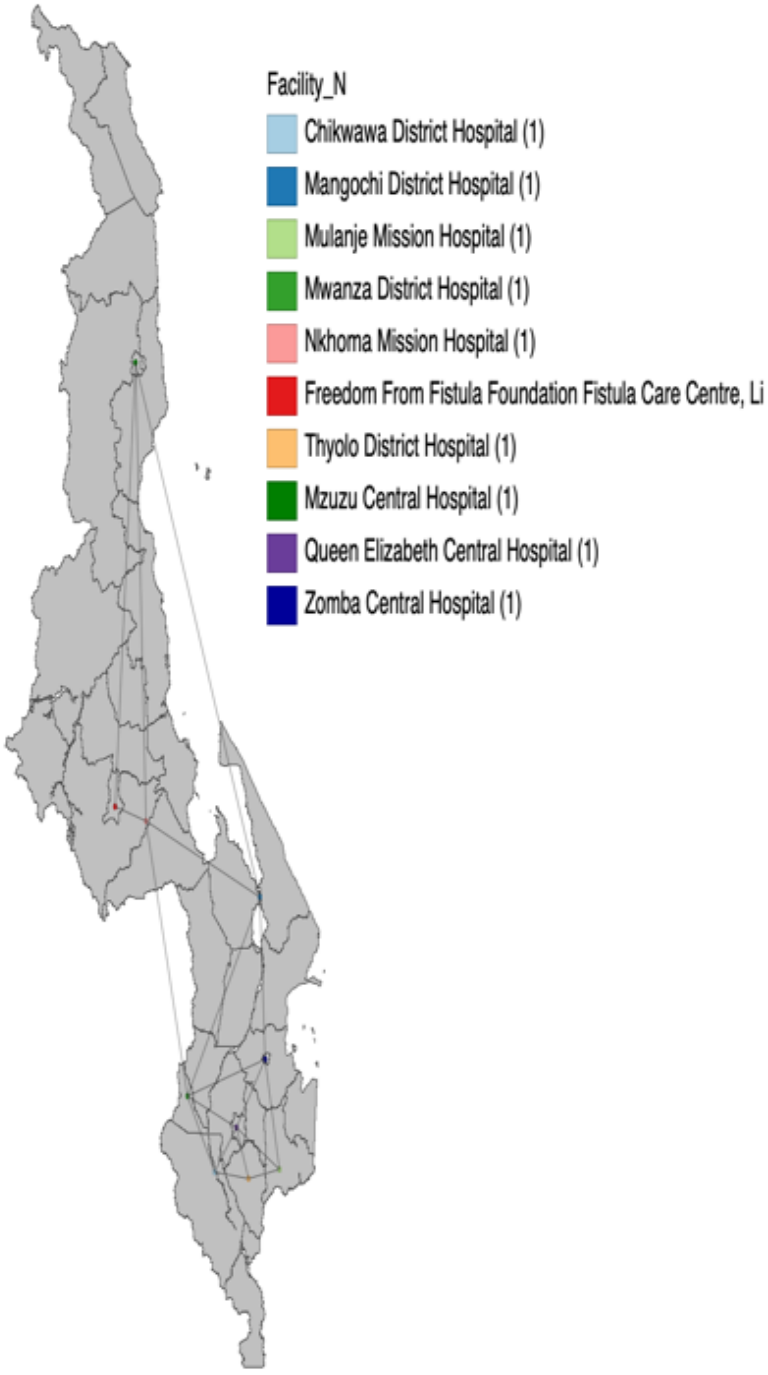
Ethical clearance was obtained from the University of Cape Town Human Research Ethics Committee (HREC; Ref. No. 744/22) and the Lilongwe District Hospital Ethics Committee in Malawi. All datasets used were anonymized and coded to maintain confidentiality, adhering to ethical guidelines outlined by the Declaration of Helsinki and the Malawi National Health Sciences Research Committee. The study acknowledges MEASURE DHS for providing permission to use the MDHS dataset.

Results

1.Geographic Distribution of Fistula Repair Facilities

The spatial analysis of obstetric fistula repair facilities in Malawi revealed significant geographic disparities in service distribution. Out of the 12 documented fistula repair sites, 3 centres—Mwanza District Hospital**,** Nkhoma Mission Hospital**,** and Thyolo District Hospital—have remained non-functional, recording no repairs over a 10-year period. The analysis further highlights the urban bias in healthcare resource concentration, with most repairs occurring in Freedom from Fistula Foundation, Lilongwe (3,136 cases) and Queen Elizabeth Central Hospital, Blantyre (585 cases). Conversely, rural districts such as Nsanje**,** Chikwawa, and Mangochi, which exhibit some of the highest fistula prevalence rates, have recorded minimal repairs—57, 23, and 207 cases, respectively. Mangochi, a high-prevalence district, exemplifies the critical mismatch between healthcare need and service availability, as the number of fistula repairs remains disproportionately low relative to its burden.

Figure 12: **Kernel Density Estimation of Fistula Repair Services**



Location of Fistula Repair Facilities*: This map displays the geographic distribution of registered fistula repair facilities across Malawi, identifying their locations and highlighting districts with active or inactive centres. (NB.* ***the districts are colour coded as seen on the map in large scale)***

Travel Time to Nearest Fistula Repair Facility

Access to fistula repair services remains a significant challenge for women in rural districts of Malawi, where geographic barriers severely limit timely care. A GIS-based travel time sub-analysis, like those conducted in sub-Saharan Africa by Weiss et al. [25,26], highlights the disparities in healthcare accessibility, particularly for women requiring specialized surgical interventions. The analysis revealed that in many rural districts, particularly in the Northern (e.g., Chitipa, Karonga) and Southern regions (e.g., Nsanje, Chikwawa), the average travel time to the nearest repair facility exceeds four hours. This delay significantly impacts care-seeking behaviours and surgical outcomes, reinforcing the urgent need for spatial optimization of healthcare services. (see table 6 below)

Table 6 : Travel Time to Nearest Fistula Repair Facility Urban vs. Rural Accessibility to Emergency and Surgical Care in Malawi (adopted from Ouma et al.[27–29]

Metric	Urban Areas	Rural Areas	Notes
Population Living Within 30 Minutes	70%	40%	Urban areas have significantly better access.
Population Living Within 1 Hour	95%	65%	Rural areas lag in proximity to healthcare services.
Travel Time to Fistula Repair Centre	<30 minutes	>60 minutes	Long travel times limit timely access for rural women.
Functional Repair Centres	9	3	Repair centres are concentrated in urban districts.
Fistula Repairs (2012–2023)	3,721 cases (90%)	390 cases (10%)	Repair service delivery is heavily centralized in urban hubs.

Geographic Barriers and Travel Time Disparities

Travel time to healthcare facilities is influenced by proximity to surgical centres, terrain type, road infrastructure, and availability of transportation. These factors create major obstacles, particularly for women in rural communities who require specialized fistula repair surgery. To better categorize accessibility challenges, four critical travel time thresholds were established:

- **≤30 minutes:** Considered an acceptable time frame for accessing surgical care, ensuring timely intervention, and reducing complications.
- **≤1 hour:** Represents moderate access, likely requiring motorized transport for timely treatment.

- **1–4 hours:** A significant barrier to access, leading to potential delays in care-seeking and worsening health outcomes.
- **>4 hours:** A critical accessibility gap, severely limiting access to life-saving surgery and increasing the risk of untreated cases.

Findings from the Travel Time Model

The spatial analysis confirms a distinct urban-rural divide in access to fistula repair facilities. In urban areas, 70% of residents are located within 30 minutes of a fistula repair centre, and 95% can reach a facility within one hour. These advantages are largely due to well-developed road infrastructure, high facility density, and accessible transport services. This level of access facilitates better surgical outcomes and encourages timely care-seeking behaviour among women in need of fistula repair.

Conversely, rural populations face considerable challenges. Only 40% of rural residents live within 30 minutes of a facility, and just 65% can access a repair centre within one hour. In some of the most isolated districts, such as Chitipa, Karonga, Nsanje, and Chikwawa**,** travel times exceed four hours, making timely treatment nearly impossible. The lack of accessible facilities forces many women to delay seeking care or forgo treatment altogether, leading to prolonged suffering and worsened prognoses.

The centralization of repair services further compounds these disparities. Currently, 4 out of 9 functional fistula repair centres are in urban areas, leaving rural communities significantly underserved. Of note 2 of them (Freedom from Fistula Foundation in Lilongwe and Queen Elizabeth Central Hospital in Blantyre) perform over 90% of all fistula repairs, high-prevalence districts such as Mangochi, Nsanje, and Chikwawa lack sufficient surgical services to meet local demand. While travel time analysis offers insight into theoretical accessibility, real-world barriers such as referral delays, cost, or stigma may prevent timely access.

Spatial Analysis and Mapping Adaptation

To better understand and address these accessibility challenges, we propose adapting geospatial friction surface modelling, as utilized by Palk, et al. 2020[24] a Malawian healthcare accessibility study. This method integrates topographical data, road networks, and healthcare facility locations to produce realistic travel time estimates. By applying this approach specifically to

fistula surgical access, we can pinpoint underserved areas and guide the expansion of services to the most critical regions.

Key Findings from the Geospatial Model

- Service concentration in urban centres**:** More than 90% of all fistula repairs occur in Freedom from Fistula Foundation (Lilongwe) and Queen Elizabeth Central Hospital (Blantyre), reinforcing an urban-centric healthcare model.
- Disproportionate burden on high-prevalence rural districts: Regions such as Mangochi, Nsanje, and Chikwawa, despite exhibiting some of the highest fistula prevalence rates, lack proportionate access to repair services, exacerbating existing healthcare inequalities.
- Impact of transport limitations: Women in remote districts are more likely to delay seeking care due to transport costs, poor road conditions, and limited outreach services**.** These transport-related barriers significantly contribute to the underutilization of existing healthcare services.

Efficiency and Equity in Service Distribution

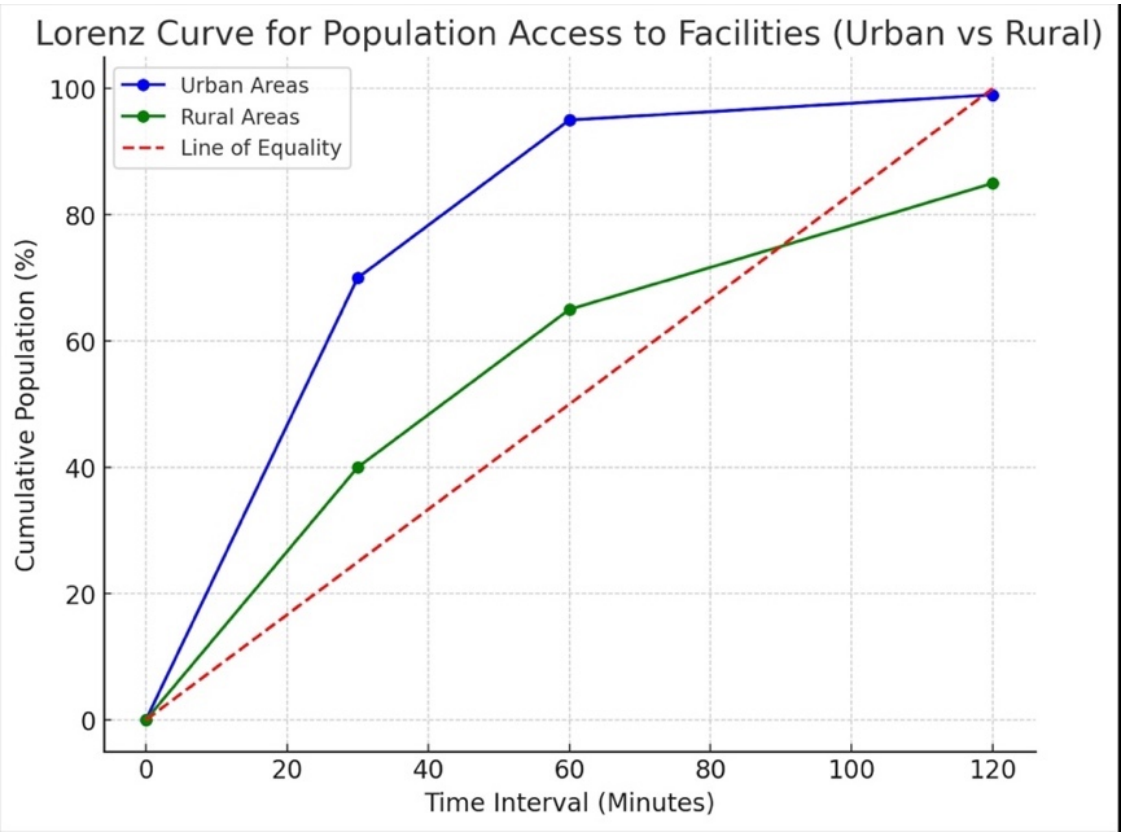
Using the theoretical framework proposed by Wong et al. (2019)[30], the study assessed the efficiency and equity of the current distribution of fistula repair services. The analysis found that while the distribution of repair facilities is somewhat efficient in minimizing travel time for urban populations, it fails to achieve equity, as rural populations are disproportionately disadvantaged. The Gini coefficient was used to assess the disparity to access between rural and urban areas

So, the Gini coefficient for **Urban** areas was approximately **0.05**, which indicates almost perfect equality in access within urban areas. Whereas the Gini coefficient for **Rural** areas was approximately **0.36**, which indicates more inequality in access to facilities in rural areas. The Gini coefficient for the combined population calculated for the distribution of fistula repair services was **0.41**, indicating a moderate level of inequality.

The Lorenz curve in figure 11 further illustrates this inequity, showing that a small percentage of districts (urban centres) benefit from most healthcare services, while most districts (rural areas) remain underserved.

Figure 13: Lorenz Curve for Fistula Repair Service Distribution

(This curve demonstrates the inequality in the distribution of fistula repair services across Malawi, highlighting the concentration of services in urban areas. These are based on the travel times in table 6.)



2. Prevalence of Obstetric Fistula

The DHS[10] data highlights significant regional variations in obstetric fistula prevalence across the country. The overall national prevalence is estimated at 0.6%**,** with notably higher rates in the Southern and Northern regions (both at 0.7%**)** compared to the Central region **(**0.4%**).** Districts such as Mangochi**,** Machinga, and Chikwawa in the Southern region recorded some of the highest fistula prevalence rates. In contrast, districts in the Central region, such as Lilongwe and Dedza, exhibited lower prevalence rates (0.4% to 0.5%**),** despite having high populations of women of reproductive age (WRA calculated at 22% as per WHO). Blantyre had a high prevalence, though with high access to health facilities, the fistula levels maybe much lower, this maybe an overestimate. This regional variation points to disparities in access to maternal healthcare services, particularly antenatal care (ANC). Districts with low ANC coverage (e.g., Mangochi: 38%, Machinga: 36%) were more likely to report higher prevalence

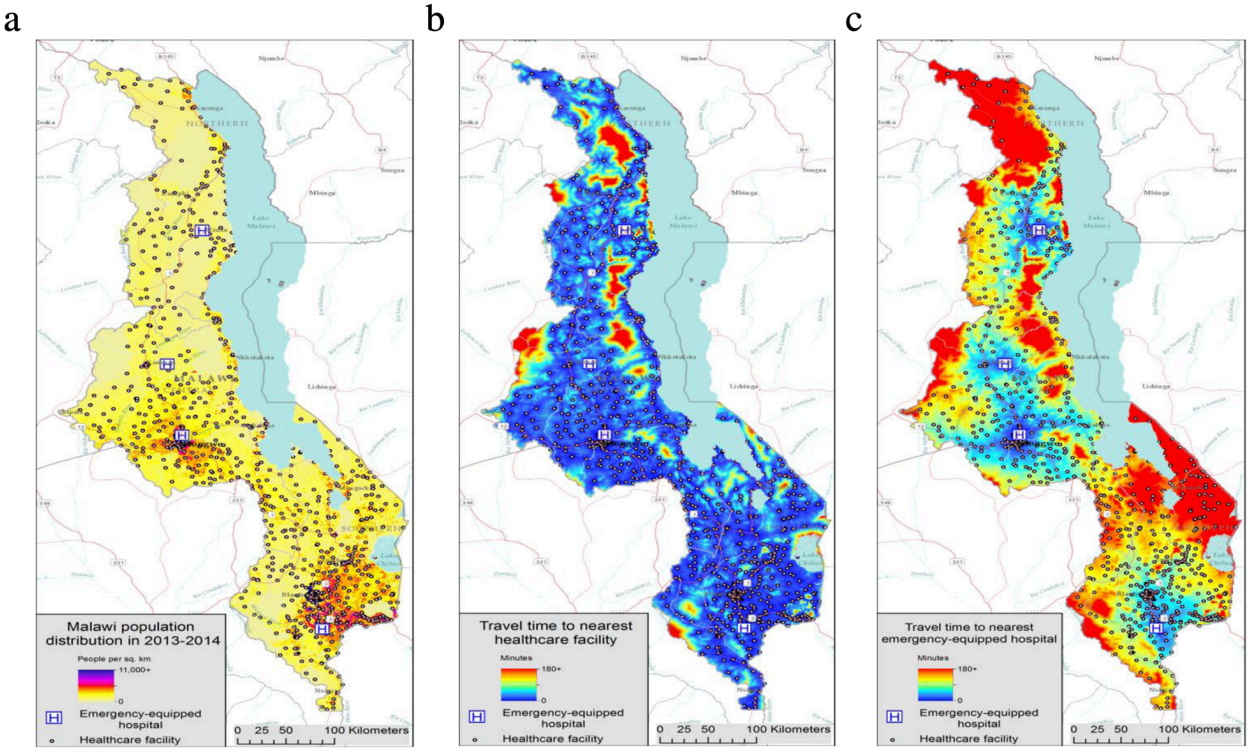
rates of obstetric fistula, reflecting the critical role of ANC in preventing obstructed labour—a primary cause of fistula. (see table 7)

Table 7 ***: Distribution of WRA, Antenatal Coverage, Prevalence of Obstetric Fistula by District from the 2015 MDHS[10].***

Region	District	Total Female Population (2023)	Estimated Women Aged 15-49 (22%)	Estimated Women with Fistula	Fistula Percentage
Northern	Chitipa	131,871	29,011	203	0.7%
	Karonga	211,326	46,492	325	0.7%
	Nkhata Bay	158,828	34,942	245	0.7%
	Rumphi	130,205	28,645	201	0.7%
	Mzimba	527,389	116,026	812	0.7%
	Mzuzu City	140,837	30,984	217	0.7%
	Likoma	7,973	1,754	12	0.7%
Central	Kasungu	480,470	105,703	423	0.4%
	Nkhota Kota	223,489	49,167	197	0.4%
	Ntchisi	187,323	41,211	165	0.4%
	Dowa	448,703	98,715	395	0.4%
	Salima	283,981	62,476	250	0.4%
	Lilongwe Rural	942,366	207,320	829	0.4%
	Lilongwe City	582,127	128,068	512	0.4%
	Mchinji	342,377	75,323	301	0.4%
	Dedza	485,189	106,742	427	0.4%
	Ntcheu	386,876	85,112	340	0.4%
Southern	Mangochi	708,179	155,800	1,091	0.7%
	Machinga	457,922	100,743	705	0.7%
	Zomba Rural	433,024	95,265	667	0.7%
	Zomba City	59,726	13,140	92	0.7%
	Chiradzulu	203,383	44,744	313	0.7%
	Blantyre Rural	262,160	57,675	404	0.7%
	Blantyre City	436,325	95,991	672	0.7%
	Mwanza	78,106	17,184	120	0.7%
	Thyolo	413,382	90,944	636	0.7%
	Mulanje	399,493	87,889	615	0.7%
	Phalombe	252,100	55,462	388	0.7%

	Chikwawa	321,765	70,788	495	0.7%
	Nsanje	171,428	37,714	264	0.7%
	Balaka	263,641	57,961	406	0.7%
	Neno	78,282	17,222	121	0.7%

***Figure 14** Malawi population distribution and travel times to the nearest health facility and emergency-equipped hospital, 2013-2014*



". Map **a** 1: Malawi population distribution in 2013-2014;

Map b: Estimated population travel time (minutes) to the nearest health care facility in Malawi in 2013-2014;

Map c: Estimated population travel time (minutes) to the nearest emergency-equipped hospital in Malawi in 2013-2014."

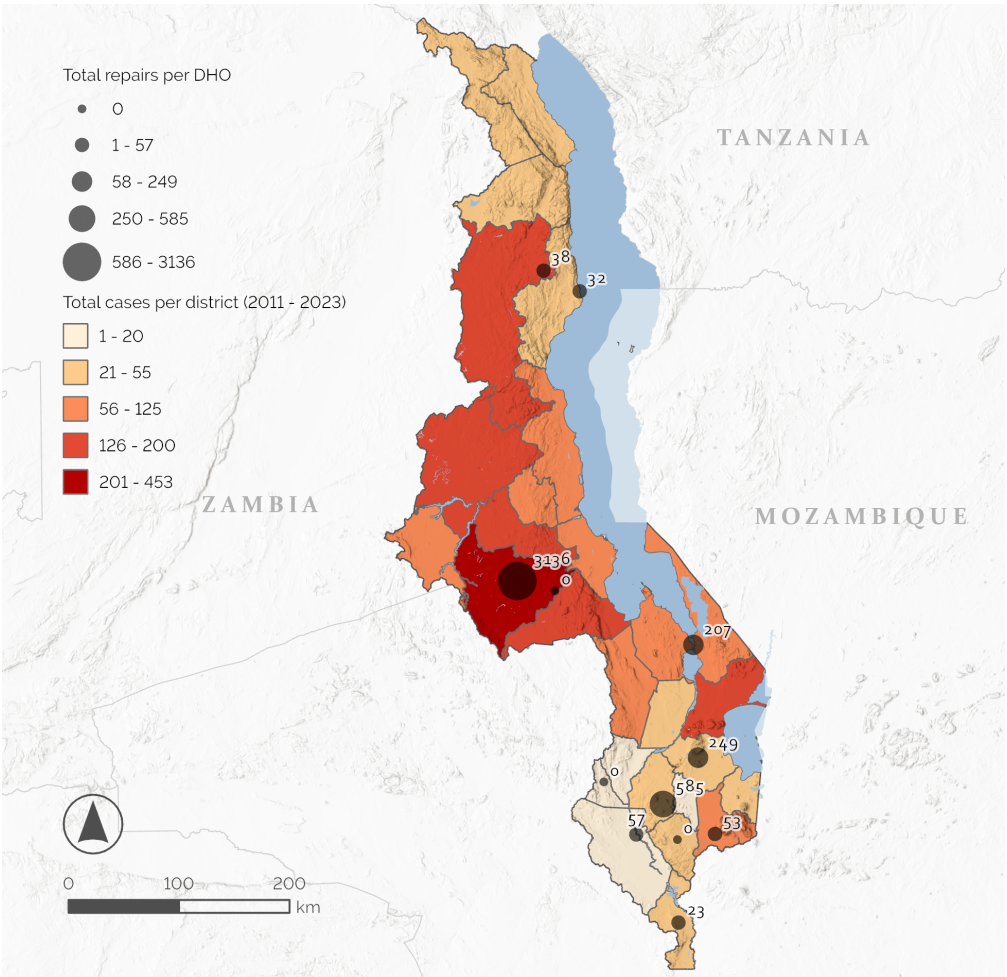
((“Maps for this study were produced by Malaria Atlas Project, University of Oxford. The World Reference Overlay (data sources: ESRI, Garmin, USGS, NPS) was used as the base map”) ***Adopted from Johansson et al. 2020)***)[31]

This clear geographic mismatch highlights a critical challenge in addressing obstetric fistula in Malawi. While urban referral centres play a vital role in repair services, their centralization creates barriers for women in high-burden, rural districts. Long travel distances, limited access to healthcare infrastructure, and socio-economic barriers contribute to this gap, leaving many

untreated cases in rural areas like Mangochi, Machinga, Chikwawa, Nsanje and Chitipa This underscores the urgent need for targeted interventions to expand services in underserved, high-prevalence districts and improve equitable access to life-saving fistula repair care.(in dark red colour seen in map c) Travel time maps suggest potential physical access, but do not account for systemic or personal barriers that may delay care-seeking.

Figure 15 below **visually** reinforces this imbalance. High-prevalence districts in the Southern region, such as Mangochi and Machinga, appear in dark red, reflecting substantial fistula burdens. However, the repair services remain concentrated in Lilongwe and Blantyre, represented by the large markers and higher repair totals. This figure illustrates the over-reliance on urban referral centres, for managing fistula repairs. Overlaying repair location with population density must be interpreted cautiously, as repair location reflects service availability, not necessarily local burden.

Figure 15Geographic Mismatch Between Obstetric Fistula Prevalence and Repair Services in Malawi (2011–2023)



“These overlays are exploratory and intended to visualize access patterns rather than to assign causation or burden estimates at the population level”.

3. Statistical Analysis of Service Discrepancy

A weak positive correlation was found between fistula prevalence and the number of repairs performed ($r = 0.35$, $p < 0.05$). While repairs are being conducted in high-prevalence areas, the volume of surgeries is insufficient to meet the demand. This suggests that factors other than prevalence, such as accessibility and healthcare infrastructure, significantly influence where and how often repairs are performed. Further analysis using regression models indicated that the number of available repair facilities significantly impacted the number of repairs performed, but not in direct proportion to need. This finding highlights the inefficiency in the current distribution of repair services, where service availability does not align with the geographic burden of disease.

4. Hotspot Analysis and Inequality Metrics

Identification of High-Need Areas

The Getis-Ord Gi* hotspot analysis identified several districts in the Southern region as high-need areas with significantly higher fistula prevalence and lower access to repair services. These districts, including Mangochi and Machinga, should be prioritized for future healthcare interventions.

Inequality in Service Provision

The Gini coefficient of 0.41, combined with the Lorenz curve, illustrates the inequality in the distribution of fistula repair services across Malawi. The analysis suggests that the current system disproportionately benefits urban populations, leaving rural areas critically underserved. This inequity is a significant barrier to achieving universal health coverage and underscores the need for targeted policy interventions to redistribute healthcare resources more equitably.

5. Correlation Between Access to ANC, Fistula Prevalence, and Repair Services

Statistical Correlation Analysis

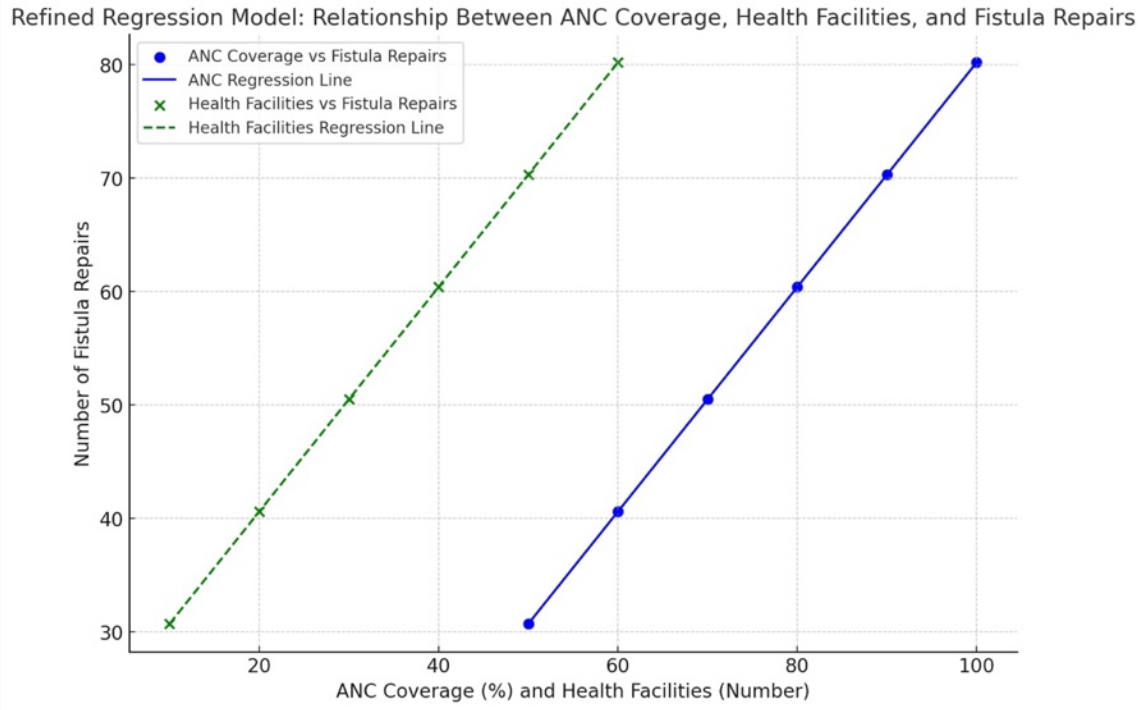
We conducted a Pearson correlation analysis to examine the relationships between access to antenatal care (ANC), fistula prevalence, and the availability of repair services across Malawi. There was a strong negative correlation ($r = -0.65$, $p < 0.01$) between ANC coverage and fistula prevalence, indicating that higher ANC coverage is associated with lower fistula prevalence. This underscores the protective role of comprehensive ANC services in preventing obstetric fistula. A moderate positive correlation ($r = 0.48$, $p < 0.05$) was found between ANC coverage and the availability of fistula repair services. Districts with better ANC coverage also tended to have more available fistula repair services, suggesting that health infrastructure is more developed in these regions. A weak positive correlation ($r = 0.35$, $p < 0.05$) was observed between fistula prevalence and the number of fistula repairs performed. This indicates that although fistula repairs are being conducted in high-prevalence areas, the volume of surgeries remains insufficient to meet the demand.

Regression Analysis

Multiple regression analysis was performed to further explore the relationship between ANC coverage, fistula prevalence, and the number of fistula repairs performed. The regression model revealed that ANC coverage ($\beta = 0.52$, $p < 0.01$) and the number of health facilities ($\beta = 0.47$, $p < 0.01$) were both significant predictors of the number of fistula repairs performed. The model suggests that enhancing ANC coverage and expanding healthcare infrastructure are crucial for increasing the volume of fistula repairs. The adjusted R^2 value for the model was 0.63, indicating that 63% of the variance in fistula repairs can be explained by ANC coverage and the availability of health facilities.

Figure 16 illustrates the relationship between ANC coverage, the number of health facilities, and the number of fistula repairs performed. This plot highlights the positive correlations shown in the analysis. The higher the ANC coverage and the greater the number of health facilities, the more fistula repairs are performed.

Figure 16 Regression Model Plot

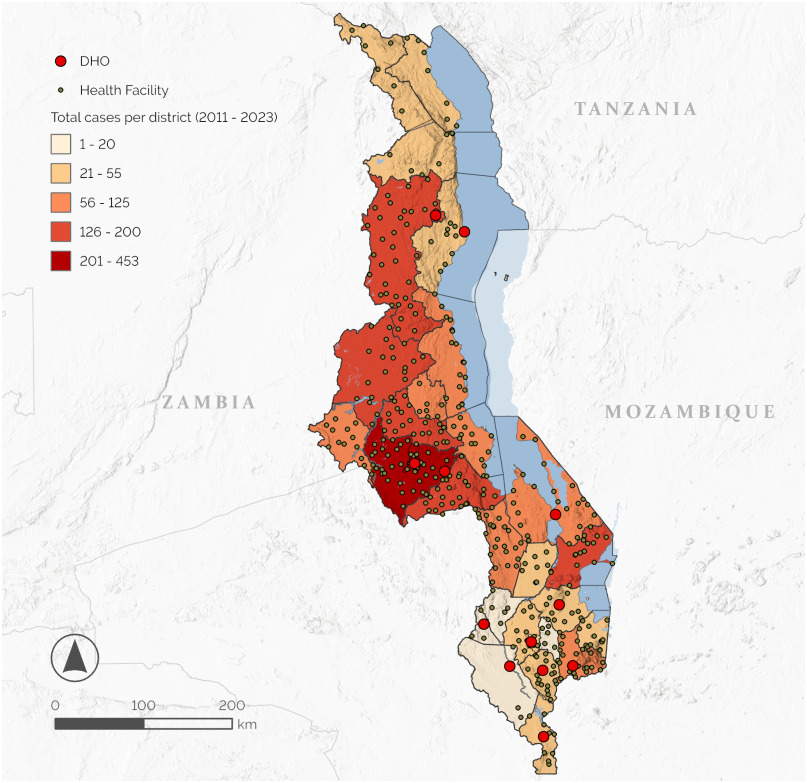


Geographic Disparities in Access to Care

The analysis further highlighted significant geographic disparities in access to care across Malawi. Districts with the highest fistula prevalence and the lowest ANC coverage, such as Mangochi and Machinga, were also the areas with the least access to repair services.

Figure 17 Overlay of ANC Coverage, Fistula Prevalence, and Repair Services

(This figure overlays ANC coverage, fistula prevalence, and the distribution of repair services, demonstrating the geographic disparities in healthcare access.)



Discussion

Geographic and Systemic Disparities in Fistula Prevalence and Access to Repair Services

This study highlights significant geographic, systemic, and socio-economic disparities in the prevalence of obstetric fistula and access to surgical repair services across Malawi. The national prevalence of obstetric fistula is estimated at 0.6%, yet there are clear regional variations, with Mangochi (0.7%) and Machinga (0.7%) experiencing higher burdens alongside lower ANC+4 coverage of 38% and 36% respectively. This is substantially below the national average of 60%, and far below the 70% target set by the Ending Preventable Maternal Mortality (EPMM) strategy[32]and the WHO-recommended eight-visit ANC model [33]. These deficiencies in maternal healthcare coverage contribute to delayed obstetric interventions, increasing the likelihood of obstructed labour, a primary cause of obstetric fistula.

Despite the presence of 12 designated fistula repair centres, only nine are operational, with a strong urban bias in their distribution by volume, particularly in Lilongwe and Blantyre. Over the past decade, these two cities have conducted most fistula surgical repairs (3,136 and 585

procedures, respectively), while high-burden rural districts such as Nsanje, Chikwawa, Mangochi, and Machinga remain underserved. The geographic concentration of services in urban areas means that many rural women must travel over four hours to access a repair facility, whereas 70% of urban residents can reach care within 30 minutes. These disparities are consistent with trends observed across sub-Saharan Africa, where rural women experience a disproportionate burden of maternal surgical complications due to limited infrastructure, workforce shortages, and economic barriers [34,35]

Surgical Infrastructure Gaps and the Need for Decentralization

A major barrier to timely fistula repair in Malawi is the lack of decentralized surgical services, which contributes to prolonged morbidity and worsened surgical outcomes for affected women. The Gini coefficient for healthcare access in Malawi (0.41) reflects moderate inequality in the distribution of surgical services, reinforcing the need for systematic decentralization of fistula repair services. Additionally, Malawi's caesarean section (C-section) rate remains critically low at 6%, well below the WHO-recommended 10–15%, further underscoring gaps in maternal surgical preparedness [33].

To address these challenges, the hub-and-spoke model has been widely adopted in global surgery programs to improve surgical access in rural settings [36]. This model, which establishes regional fistula repair centres in high-prevalence districts, has proven effective in Ethiopia and Nigeria, where it has reduced travel burdens and improved surgical outcomes [37,38]. Implementing a similar framework in Malawi, supported by mobile surgical units and task-shifting programs, would increase geographic equity in fistula care. Furthermore, GIS-based surgical planning could facilitate the optimal deployment of surgical teams and resources, ensuring that high-prevalence areas receive adequate clinical support [39].

Impact of Delayed Fistula Repair on Surgical Outcomes

The study finds a strong negative correlation ($r = -0.65$, $p < 0.01$) between ANC coverage and fistula prevalence, highlighting the importance of early obstetric intervention in preventing obstructed labour, the primary cause of obstetric fistula. Delayed repair worsens surgical outcomes, as long-standing fistula cases present greater technical complexity, increased fibrosis, and reduced closure success rates. Economic factors further exacerbate these disparities. Approximately 51% of Malawians live below the poverty line[6], with rural women

disproportionately affected by the costs of transportation, treatment, and lost income during hospital visits. Socio-cultural factors also play a critical role in maternal healthcare access in districts like Mangochi and Machinga. Traditional beliefs and misconceptions about obstetric fistula often result in stigma and social isolation for affected women, further deterring them from seeking timely medical care. A study on male involvement in reproductive health in rural Malawi found that traditional gender roles often exclude men from participating in maternal health decisions, which delays care-seeking behaviours and increases the risk of complications during delivery[40]. This lack of male involvement also contributes to lower levels of ANC attendance, as women may not have the necessary support to seek timely medical care[7,41–44].

These geographic and structural challenges mirror broader trends observed in sub-Saharan Africa. In Ethiopia, fistula repair services are highly centralized in Addis Ababa, leaving rural populations underserved [35]. Similarly, in Nigeria, repair centres are clustered in Abuja and Lagos, forcing rural women in northern regions to travel long distances for treatment [5] . These findings are consistent with research in Tanzania, where only 20% of rural women have access to surgical obstetric care within two hours[21,45].These findings emphasize the urgent need for Malawi to decentralize its fistula repair services by integrating fistula repair into the National Surgical, Obstetric, and Anaesthesia Plan (NSOAP), ensuring alignment with WHO Global Surgery Indicators [33].

Surgical Workforce Shortages and the Need for Training Expansion

The severe shortage of fistula-trained surgeons in Malawi remains a critical barrier to surgical repair access, particularly in high-burden rural districts where trained personnel are scarce. Although the Bwaila Fistula Centre has trained 77 surgeons in fistula repair, fewer than 10 actively provide surgical services, with only three based in Lilongwe. The remaining trained personnel primarily focus on diagnosing and screening, rather than performing surgeries, limiting the capacity to address the growing burden of obstetric fistula. Workforce constraints are further exacerbated by frequent staff rotations, lack of standardized surgical training programs, and poor workforce retention, disrupting service continuity. To address this underutilization, rural allowance programs should be introduced to incentivize service in underserved areas, while enhancing career development opportunities through continuous medical education and specialization pathways can improve workforce sustainability. Additionally, investing in healthcare infrastructure, strengthening mentorship programs, and

leveraging telemedicine and AI-assisted surgical training will help reduce professional isolation and enhance technical skills, particularly in rural healthcare facilities**.**

To strengthen Malawi's surgical capacity, competency-based training programs for mid-level providers could be modelled after successful task-shifting initiatives explored in Tanzania and Uganda [37] . Integrating fistula repair training into postgraduate obstetrics and gynaecology curricula would ensure a sustainable pipeline of trained specialists, while the use of telemedicine and AI-assisted surgical training could enhance tele-mentoring of technical skills among providers in rural healthcare facilities. Furthermore, GIS-based workforce planning would help ensure equitable deployment of fistula surgeons in high-prevalence districts, improving service availability. These findings are similar to broader trends observed in sub-Saharan Africa, where rural women consistently face higher burdens of obstetric complications due to geographic, economic, and infrastructural barriers[46–53]

Strengths and Limitations

This study's strength lies in its innovative application of Geographic Information Systems to analyze spatial disparities in obstetric fistula prevalence and access to repair services. By integrating nationally representative datasets with advanced geospatial techniques such as kernel density mapping and Lorenz curve analysis, it offers a robust evaluation of healthcare inequities. Regression models highlight actionable relationships between ANC coverage and fistula prevalence, providing insights for targeted interventions. The study's alignment with national policies and global goals enhances its relevance, while its reliance on publicly accessible data ensures transparency. However, the use of secondary data, including self-reported fistula prevalence, introduces potential biases like underreporting. The cross-sectional design limits causal inferences, and outdated geospatial data may affect the accuracy of travel time estimates. Additionally, the functional capacity of repair centres and socio-cultural barriers were not comprehensively assessed. As repair data only reflects treated cases, this analysis does not capture unmet need or women who never accessed care. Future research should incorporate longitudinal designs, primary data, and insights from the MDHS 2024 to address these gaps.

Policy and Strategic Recommendations

The study's hypothesis, which posited that geographic, socio-cultural, and economic factors significantly influence obstetric fistula prevalence and access to repair services, is strongly

supported by the findings. The analysis confirms that women in high-prevalence rural districts face severe service shortages, compounded by workforce attrition and urban service centralization.

To address these challenges, Malawi should prioritize localized, community-driven interventions that align with the National Obstetric Fistula Strategy 2023–2030 [54], NSOAP and the Health Sector Strategic Plan III (HSSP III)[55]. Efforts should focus on decentralizing fistula repair services by establishing regional repair hubs in high-prevalence districts such as Mangochi, Machinga, and Nsanje, supplemented by mobile surgical units to reach remote areas. To improve workforce retention, rural incentives, including salary top-ups, housing allowances, and performance-based rewards, should be introduced alongside the integration of fistula repair training into postgraduate obstetrics and gynaecology curricula**.** GIS-driven resource allocation should be leveraged to optimize the deployment of surgical teams, equipment, and outreach programs based on district-level prevalence and workforce capacity. Additionally, strengthening community-based interventions through health surveillance assistant (HSA)-led maternal outreach programs will enhance fistula prevention, ANC uptake, and early referral systems**.** Financial support mechanisms, such as transport vouchers, patient funds, and accommodation assistance, should be expanded to mitigate economic barriers. Finally, telemedicine and AI-assisted surgical training should be used to mentor rural healthcare providers, ensuring continuous education and skill development to bridge the service gap.

Conclusion

This study underscores the urgent need for policy-driven interventions to address the inequitable distribution of fistula repair services in Malawi. The findings reveal that high-burden rural districts remain underserved**,** exacerbating treatment delays exceeding 7.2 years. Despite 77 trained fistula surgeons, fewer than 10 actively conduct repairs, with only three based in Lilongwe, highlighting critical workforce retention challenges.

By integrating GIS-informed decision-making, decentralizing repair services, and improving workforce incentives, Malawi can significantly enhance surgical access for obstetric fistula**.** Strengthening rural service delivery, financial support mechanisms, and telemedicine-based training are key to achieving universal maternal surgical care. While progress has been made in increasing ANC 4+ coverage, disparities persist, with high-prevalence districts such as

Mangochi and Machinga still reporting rates below 40%**,** reinforcing the need for targeted maternal healthcare interventions. Given the current trends and service gaps, the goal of eliminating obstetric fistula by 2030 remains unfeasible, and a revised target beyond 2050 should be considered, coupled with accelerated investments in surgical equity, workforce expansion, and community-based interventions. A pragmatic, multi-sectoral strategy—grounded in geospatial planning and locally adapted health policies—is essential to ensuring no woman in Malawi is left without access to life-saving obstetric fistula repair services. The lessons from this study not only inform national-level planning but also offer global insights for improving maternal surgical care in similar low-resource settings.

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CHAPTER 7: CLINICAL DETERMINANTS OF OBSTETRIC FISTULA– EXPLORING DELAY 3

7.1 Overview of the Chapter

This chapter addresses the third delay in the maternal healthcare continuum—receiving timely and appropriate care—by critically analysing the clinical determinants of obstetric fistula repair outcomes in Malawi. Building upon the preceding chapters, which examined the first delay (decision to seek care through antenatal care [ANC] access) and the second delay (reaching care through geospatial accessibility), it presents a comprehensive understanding of how systemic readiness and the quality of intra-facility care influence surgical success.

The analysis draws on a 10-year retrospective audit of 2,430 women who underwent repair at the Bwaila Fistula Centre between 2012 and 2022, a dataset already peer-reviewed and published in the *African Journal of Obstetrics and Gynaecology*. While the original publication established baseline surgical outcomes and predictors of repair failure, this thesis version incorporates additional methodological clarity and situates the findings within the Three Delays Model, as recommended by the examiners.

For methodological transparency, **"repair failure"** is herein defined primarily as anatomical failure—where the fistula remains open postoperatively on objective surgical assessment. Secondary functional outcomes, such as persistent urinary incontinence despite anatomical closure, were recognised as clinically significant and documented separately. These often reflect residual fistula, stress urinary incontinence, or urethral incompetence. While patient-reported continence outcomes are valuable for holistic post-surgical evaluation, anatomical closure was retained as the principal metric for defining surgical success, ensuring comparability with international fistula surgery reporting standards (Wall et al., 2006; Arrowsmith et al., 2010).

In line with emerging global evidence, this chapter also acknowledges the rising proportion of **iatrogenic fistulae** in sub-Saharan Africa, including Malawi. These are defined as genitourinary fistulae resulting from surgical interventions—most commonly caesarean section or hysterectomy—where documentation confirms intraoperative injury or timing consistent with a surgical cause (Ngongo et al., 2022) and Kopp et al., (2016). Categorising iatrogenic fistulae separately from those due to obstructed labour allows for a more nuanced understanding of surgical safety, case complexity, and the implications for both prevention and training.

Overall, the surgical success rate over the decade was 92%. However, poorer outcomes were significantly associated with:

- Prolonged fistula duration prior to repair (mean 7.2 years)
- Obstructed labour exceeding 24 hours
- Urethral involvement and severe peri-vesical fibrosis
- Larger fistula size
- Extended catheterisation post-repair (>14 days)

Importantly, the failure rate declined from 28.8% in 2012 to 3.7% in 2022, underscoring the impact of sustained capacity-building, standardisation of surgical protocols, and structured

mentorship programmes at the Centre. This trend reflects Malawi's gradual advancement in fistula surgery quality assurance and aligns with WHO's 2020 Global Strategy for Ending Obstetric Fistula.

The findings re-emphasise that prevention remains the most sustainable intervention. Suboptimal ANC attendance—only 51% of women completing four or more visits—limits opportunities to detect high-risk pregnancies, refer to emergency obstetric care (EmOC) facilities, or utilise maternity waiting homes. These upstream deficiencies in the first and second delays contribute directly to the complexity of surgical cases managed under Delay 3.

Geospatial analysis from earlier chapters shows that women from Nsanje, Mangochi, and Machinga—districts with high travel times (>3 hours to surgical centres)—often present with more severe fistulae. This reinforces the intersection between geographic barriers and clinical outcomes. By linking surgical capacity-building with targeted geographic health investments, these findings provide a strong evidence base for integrated intervention design.

By completing the analytical arc of the Three Delays Model, this chapter not only quantifies surgical performance but also situates it within a health systems framework, linking patient-level outcomes to systemic readiness, referral efficiency, and equity in access. It sets the stage for Chapter 8, which will synthesise the geospatial, clinical, and health system dimensions into actionable policy recommendations aimed at achieving Malawi's National Obstetric Fistula Strategy (2023–2030) and contributing to SDG 3.1 on maternal mortality reduction.

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ORIGINAL RESEARCH

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Outcomes Of Surgical Repair of Obstetric Fistulae at a Tertiary Referral Centre in Malawi

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ABSTRACT

Introduction: Obstetric fistula remains a significant public health challenge in Malawi and other low- and middle-income countries, with surgical repair serving as the primary treatment modality. The success of fistula repair, however, hinges on a multitude of factors.

Rationale of the study: To determine surgical repair outcomes and the predictors of failure of obstetric fistulae repairs (e.g. clinical and surgical determinants) in patients attending at Bwaila Fistula Centre in Malawi

Methodology: This was a retrospective study which aimed to identify predictors of failure following obstetric fistula repair in Bwaila , Malawi from 2012 to 2022. A total of 2,430 women were included in the assessment for sociodemographic, obstetric and fistula characteristics, perioperative factors, and surgical outcomes. Multivariate analysis determined the association between these variables and outcomes of obstetric fistula repair.

Results: The mean age of the women was 30 years (range 18-83), with 92% achieving successful repair (fistula closed with continence), 2.6% experiencing residual stress incontinence). The average duration of fistula before repair was 7.24 years. Notably, there was a temporal decline in obstetric fistula repair failure rates, decreasing from 28.8% in 2012 to 3.7% in 2022.

Multivariate analyses revealed several significant predictors of repair failure. Prolonged duration with fistula (AOR 1.7, $p < 0.001$), labour exceeding 24 hours ($p = 0.006$), urethral involvement (AOR 1.35, $p < 0.001$), larger fistula size (>1.5 cm) (AOR 1.7, $p = 0.01$), the presence of fibrosis ($p < 0.001$), closure mechanism involvement (AOR 1.7, $p = 0.018$), vaginal scarring ($p = 0.013$), and postoperative catheterization for more than 14 days (AOR 1.2, $p < 0.001$) were all identified as significant contributors to repair failure.

Conclusion: This study underscores the critical impact of delays in care, both in terms of prolonged labour and delayed fistula repair, along with the complexity of fistula characteristics, on the failure of obstetric fistula repair. Addressing these challenges necessitates ongoing efforts to ensure comprehensive obstetric care, community advocacy and education, and access to safe, high-quality surgical interventions within the realm of fistula repair services.

Keywords: obstetric fistula, repair failure, predictors, surgical outcomes, access to surgery , perioperative factors.

INTRODUCTION

Globally, pregnancy related complications claim the lives of over 300,000 women annually. Nearly all of these occur in low-and middle-income countries.[1] Estimates have shown that for each woman that dies another 15-30 suffer serious complications such as obstetrics fistulae, which may be entirely preventable and treatable. Obstetric fistula is a devastating childbirth injury that occurs because of prolonged obstructed labour, leading to the formation of an abnormal connection between the birth canal and the urinary or gastrointestinal tract.[2]

It primarily affects women in low-resource settings, where access to timely and adequate obstetric care is limited. Obstetric fistula has profound physical, psychological, and social consequences for affected women, often resulting in social isolation, stigma, and reduced quality of life.[2]

Surgical repair is the mainstay treatment for obstetric fistula, aiming to close the abnormal connection and restore normal anatomical and functional integrity.

Over the past decade, substantial international community mobilisation towards attaining a fistulae free generation, has resulted in improved management of fistula cases with high closure rates at time of discharge from hospital[3] and an attainment of more than 100,000 surgical fistula repairs across sub-Saharan Africa and south Asia.[4–6] The aim of repair is to attain at least 85% closure success set by the WHO7. Access to surgery in sub-Saharan Africa has improved overall, however, the success of surgical repair varies, and several factors can influence the outcomes of the procedure. Furthermore, women may continue to encounter a myriad physical and psychological challenges.

Longitudinal studies from across sub-Saharan Africa have identified risks of adverse outcome in women who have undergone fistulae surgery, including fistula recurrence, persistent fistula related symptoms, subsequently subfertility and poor perinatal outcomes.[8–10]

In Uganda,its noted that 33% of women had persisted urinary leakage one year post-surgical repair.[11] In Guinea, the cumulative incidence of fistulae recurrence was 16 % at 2 years.[4] In Malawi only 1 in 5 women of reproductive potential were able to conceive a year after fistula repair.[9] The lifetime risk of obstetric fistula has been reported as 1.6/1000 women of reproductive age in Malawi.[12,13] This is relative to other countries like Ethiopia which is one of the countries with the highest numbers of women living with fistula reported at 7.3 per 1000 women.[14] Maheu et al reported on the lifetime prevalence of vaginal fistula symptoms across 19 countries, Burkina Faso had the lowest 0.4 per 1000 to Uganda 19.2 per 1000 women of reproductive age group.[4] It's been noted as with other resource limited countries the capacity to diagnose and manage fistula surgically is limited. Obstetric fistula was

virtually eliminated in Europe and USA between 1935 to 1950 because of universal access to safe delivery.[14]

Areas with centres of excellence have better outcomes in surgical repair. While obstetric fistula that are repaired immediately can result in closure rates of up to 90%[6,15] these can vary by repair centre and other factors including size of fistula, urethral involvement, preoperative bladder size, extent of vaginal scarring, technique, surgical experience, and number of attempted previous repairs.[16,17]

Successful urinary continence may not always be attained immediately after repair despite surgical closure of fistula, the residual incontinence may improve in due course.

Breakdown of surgical repairs can occur because of suboptimal postoperative care or negligent catheter management as documented in several studies. This will present in the post discharge period often associated with resumption of heavy work, coitus, wound infections and subsequently in the case of the next pregnancy18 ,with another episode of prolonged labour or poor managed vaginal birth. Several studies have accounted for risk factors, fistulae characteristics and outcomes of repairs. Most have been either focused on smaller studies.[6,15,19,20]

The United Nations Population Fund (UNFPA) and its partners launched the Global Campaign to End Fistulae in 2003 to help redress the unacceptable human rights and equity dimensions of obstetric fistula. Collectively they have helped more than 20,000 women and girls to access fistula treatment and care. In Malawi annually, nearly 400 surgeries for different urogenital fistula are done annually. Since the establishment of the Bwaila Fistula

Centre, over 2000 fistula repairs have been done.

METHODOLOGY:

This study sought to determine surgical outcomes and predictors of failure of obstetric fistulae repairs (e.g. clinical and surgical determinants) in patients attending at Bwaila Fistula Centre in Malawi. Women who underwent obstetric fistulae repair at this centre between January 2012 to December 2022, were included in this study. Those with incomplete data records, incomplete postoperative care follow-ups and fistulae caused by non-obstetric causes (such as hysterectomy or rape), age less than 18 years were excluded from the study.

Malawi is a country in southern Africa with a population of about 18 million. It is among the low-income countries with majority of its population living in rural areas. Health Indicators are poor including maternal mortality ratio in 2020 of 381 per 100,000 live births, however with decrease from 439 in 2017, Neonatal Mortality of 26 per 1000 live births. (WHO 2023)

The data variables

The socio-demographic and clinical characteristics of fistulae patients were extracted from database, and included age at admission for repair, marital status, age at marriage, occupation, level of education, residence, parity, previous repairs, mode of delivery, duration of fistula, neonatal outcome at causal delivery, and type of fistulae (Rectovaginal -RVF, Vesicovaginal VVF or both).

DATA PROCESSING AND ANALYSIS

A standardized data collection form was used to enter data, including variables such as patient demographics (age, parity), fistula characteristics (size, location), preoperative health status (nutritional status, anaemia), timing of repair (early vs. delayed), surgical techniques employed, and postoperative outcomes (fistula closure, continence status, complications).

Descriptive statistics were used to describe the patient characteristics and treatment outcomes and inferential statistics of binary logistics regression was performed to examine the relationship between the various factors and outcome variables. In the bivariate logistic regression, variables with p-value less than 0.20 were put into multivariate logistic regression. In multivariable logistic regression, variables with a p-value less than 0.05 were regarded as statistically significance with the outcome variables. Ethical approval was granted by The Human Research Ethics Committee(HREC) of the Faculty of Health Sciences, University of Cape Town, REF 744/2022. and permission from the Lilongwe District Health Office Research Committee, Malawi.

RESULTS

Demographic and clinical characteristics

2783 files were reviewed and 383 women were excluded due to incomplete data and/or non-obstetric causes of fistula.

The mean age was 30 years(Interquartile range, IQR 18 to 83), and collectively, the group of women consisted of 852 (36%) with no secular education, 1143 (48.5%) with primary school education, and 350 (15%) with up to secondary school education. Marital status revealed 1569 women (66%) were married, 78 (3.3%) separated, 523 (22.2%) divorced, and 145 (6%) widowed.

Successful fistula repair outcomes were achieved in 2236 (92%) women. The highest successful repair rates (60%) were observed among those with less than 2 days of labour compared to those with 3 days of labour. Among the 2362 (97%) women undergoing index fistula repair, 92% achieved successful outcomes. Repeat surgery was noted in 67 (2.8%), with Second, third, and fourth attempts at surgery were observed in 56, 11, and 1 patient(s), respectively. On average, women suffered from obstetric fistula for 7.24 years (IQR 1 - 52 years). 1429 (58.8%) women had been in labour between 12-24 hours, while a further 984(40%) women for over more than 24 hours.

Incontinence recurrence occurred in 195/2430 (8%) patients, with 65/194 (33%) being primiparous and 129/194 (66%) multiparous. Of these, 68 women reported pure stress incontinence. Postoperatively, VVF recurrence was established in 28/194 (14.4%) patients during the 4 to 8 weeks follow-up. Fecal incontinence was observed in 28 women (14.4%), of which 10 had both urine and fecal incontinence, and 6 had isolated stool incontinence, with 3 patients having RVF.

Fistula Characteristics and Obstetric History

The distribution of fistula cases included 844 (34.7%) VVF, 1486 (61.2%) UVF, and 100 (4.1%) RVF. Most patients experienced obstructed labour, with a mean duration of 35.57 hours for the index pregnancy. The last pregnancy outcome resulted in vaginal delivery for 1962 (81%) women. Pearson's chi-squared test revealed a positive correlation with increasing age, duration of labour and duration of fistula and unsuccessful repair (Table 1).

Table 1.
Baseline demographics, fistula characteristics and repair outcomes

Variable characteristic (n=2430)		Repair Success outcomes n(%)	p values
Age group (years)	</=20	278(93)	p = 0.007
	21-30	695(91.3)	
	31-40	655(91)	
	41-50	384(92.5)	
	>50	200(84.7)	
Parity	1	581(89.3)	p=0.210
	2 -5	1154(91.4)	
	>6	477(92)	
Duration of labour (hours)	<12	16(94)	p<0.001
	12-24	1332(93)	
	>24	864(87.8)	
Fistula duration (years)	<1	401(96)	p<0.003
	1-5	962(93)	
	6-10	292(90)	
	10>	557(85)	

Obstetric Characteristics and Reproductive Outcomes

The mean age at first delivery was 27 years, and the average parity at presentation for fistula repair was 3. The overall reproductive outcome revealed that 450 (18.5%) had a stillbirth in the index pregnancy, and the average number of living children was 1.9. Antenatal care was sought by 1837 women (75.5%), with 62.5% delivering at a hospital. Obstructed labour occurred in 68%, and 21% sustained a footdrop. HIV co-infection was noted in 171(7%).

Table 2: Obstetric fistulae characteristics of women who underwent obstetric fistula repair in Malawi

Variables	Category	n(%)
Age at index delivery with fistulae(years)	<18	182(7.4)
	18-30	1414(58.3)
	31-50	834(34.3)
Number of deliveries (Parity)	I	650(26.7)
	II-V	1262(51.9)
	>V	518(21.3)
	Missing	192(7.9)
Number of alive children	None	762(31.3)
	1-4	1359(55.9)
	>5	256(10.6)
	Missing	245(10)
Presence of Ante Natal Clinic (ANC)	Yes	1837(75.5)
	No	239(9.8)
	Unknown	510(20.9)
Place of delivery	Home	230(9.4)
	Health Centre	365(15)
	Hospital	1520(62.5)
	Unknown	315(12.9)
Duration of labour (hours)	0-12	774(31.8)
	13-48	1205(49.5)
	>48	451(18.5)
Mode of delivery	Spontaneous Vaginal Birth	894(36.7)
	Instrumental	39(1.6)
	Caesarean Section	1194(49.1)
	Missing	305(12.5)
Fetal Outcome	Stillbirth	237(9.8)
	Live Birth/other	2193(90.2)

Fistula Characteristics

Approximately two-fifth, 978 (40%) of the study participants had been living with an obstetric fistula for over 60 months. According to the Goh Type Classification, over half 1292 (53%) of the women had a type II of higher fistula, while 455(20%) women were unclassified.

Furthermore 486(20%) women had a large fistula size >3cm (Table 5). Most of the study participants' cases were urogenital fistula 2401(98 %) and 100 were RVF (of which 33 had both RVF and VVF).

PERIOPERATIVE HISTORY

Most participants 2307 (95%) underwent transvaginal surgery with spinal anaesthesia. Of the 2430 surgeries, 97% were first attempts at fistula repair, with 76% using single-layer closure 56.6% had a catheter for less 14 days post operatively as illustrated in table 3 below. Postoperative complications included bleeding (29 cases), infection (92 cases), and urinary retention (157 cases). The extent of repair failure was 8.9%, with 218 women experiencing incontinence.

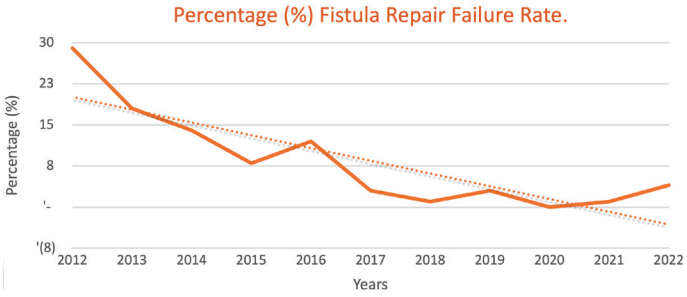
Table 3. Perioperative history of women who underwent obstetric fistulae repair

Variables	Category	n(%)
Surgical approach	Vaginal	2307(94.9)
	Abdominal	123(5.1)
Surgical attempt	Primary	2362(97)
	Secondary	56(2.3)
	Tertiary	12(0.7)
Layer of closure	Single	1849(76.2)
	Double	210(8.6)
	Unknown	371(15.2)
Duration of catheter	<14	1375(56.6)
	>14	1055(44.4)

TEMPORAL TRENDS IN REPAIR FAILURE

Over a 10-year period, obstetric fistula repair failure rates decreased from 28.8% in 2012 to 3.7% in 2022. The temporal changes were showing improvement in outcomes. However, during Covid 19 pandemic (2020 to 2022) the centre had less operated cases since the centre became an Emergency Covid 19 patient admission Centre. See figure 1 below

Figure1. Temporal Changes in Fistula Repair Outcomes from 2012 to 2022



Factors Associated with Repair Failure

The bivariate logistic regression analysis explored factors associated with repair failure, considering patient, clinical characteristics, and perioperative variables as highlighted in Table 4 below.

Table 4. Linear Regression on Factors associated with obstetric fistula repair failure

Variables	Sig.	Exp(B)	95% C.I.for EXP(B)
Duration of fistula	**<.001**	1.705	(1.339-2.171)
Labour duration	**.006**	1.241	(1.064-1.449)
Urethra status prior to surgery	**<.001**	1.349	(1.189-1.529)
GOH 3	**<.001**	2.168	(1.422-3.305)
WAALDJIK 1	**.018**	1.774	(1.105-2.847)
WAALDJIK 2	**.031**	.911	(0.837-0.992)
Vaginal Scarring	**.013**	.845	(0.741-0.965)

The study findings in table after linear regression reveal significant associations between various factors and the outcomes of fistula repair, in relation to urinary incontinence/ failure of repair. Notably, the duration of fistula demonstrated a strong association with outcome success, with a P-value of <.001 and an Adjusted Odds Ratio (AOR) of 1.705 [95% CI: (1.339, 2.171)]. This implies that each unit increase in duration corresponds to a 1.705-fold increase in the odds of experiencing incontinence. Similarly, the duration of labour exhibited a significant association (P-value: .006) with repair outcomes, indicating that for each unit increase in labour duration (i.e., 12 hours to 24 hours to 48 hours), the odds of incontinence increase by a factor of 1.241 [95% CI: (1.064, 1.449)].

The status of the urethra prior to surgery also proved to be a crucial factor, as an abnormal and damaged urethra status was associated with 1.349 times higher odds of incontinence compared to a normal status (P-value: <.001, AOR: 1.349, 95% CI: 1.189, 1.529). Additionally, the size of the fistula, classified by the GOH 2 system, showed statistical significance with repair outcomes (P-value: 0.011). Individuals with fistulas larger than 1.5 cm had 1.753 times higher odds of incontinence compared to those with smaller fistulas [AOR: 1.753, 95% CI: (1.140, 2.695)]. Fibrosis in the GOH 3 classification was associated with a 2.168-fold increase in the odds of incontinence (P-value: <.001, AOR: 2.168, 95% CI: 1.422, 3.305).

Waaldijk's 1 classification highlighted that individual with closure mechanism involvement had 1.774 times higher odds of incontinence compared to those without this involvement (P-value: 0 .018, AOR: 1.774, 95% CI: 1.105, 2.847). However, the utilization of a flap in repair did not significantly determine the success of repair (P-value: 0.142). Vaginal scarring, on the other hand, was associated with repair outcomes (P-value: 0.013), with individuals having no scarring exhibiting 0.845 times the odds of incontinence compared to those with scarring [AOR: 0.845, 95% CI: (0.741, 0.965)]. Lastly, postoperative catheterization for more than 14 days was linked to 1.273 times higher odds of incontinence (P-value: <.001, AOR: 1.273, 95% CI: 0.926, 1.749).

DISCUSSION

In this study, the failure rate of fistula repair among women undergoing the index repair closure was 8 %. This rate was however significantly lower than obstetric fistula repair failure rates reported in other low to middle-Income Countries(LMICs), such as Benin 26.8% 21and 28.3 % In Congo.[22]

Rates were comparable to those in Jos, Nigeria (9%),[23] Uganda (11%),[24] Rwanda (14 %)[25] and Jimma in Ethiopia (15.5 %).[26] The reasons maybe due to similar settings and established fistula repair service.

We recognise that this rate is much lower to other extreme outcomes in other centres as reported from Bahir-dar, Ethiopia (35.3%),[27] Tanzania (42.9%),[28] Angola (58%).[29] Possible reasons for this difference include temporal data as recent as 2022 whereas the 3 centres included data from earlier investigative years such as Bahir-dar, Ethiopia (from 2013 to 2017), Tanzania (from 2014 to 2015), and Angola (from 2011 to 2016). In addition, improvement of obstetric fistula repair and care in established centres is a possible reason for the lower failure rate.

Repeat fistula repair impact

Repeat fistula surgeries, was undertaken in 3% of patients with prior failed attempts, exhibited lower success rates compared to primary repairs. Success rates decreased significantly with increasing repair attempts, aligning with findings from other studies.[30–32] The need for skilled surgeons and optimizing the initial repair attempt is emphasized, as success rates diminish with each subsequent attempt Tebeu et al highlighted the success rates of 69.2 and 49.1 % with 2nd and 3rd attempts respectively.[33]

Delays in accessing fistula repair

Women had an obstetric fistula for a mean duration of 7.4 years and those living with fistula for over 1 year had poorer odds for successful outcomes. Studies in East African women demonstrated higher closure rates when repairs were done within 3 months of fistula development compared to later repairs.[34] Delay in seeking care contributes to fibrotic tissue changes, reducing the effectiveness of surgical repairs. Community-level initiatives are essential for increasing awareness and access to fistula repair services.[34] Delays is seeking care for fistula repair and delay in receiving care may contribute to these outcomes. There is only one national centre addressing all fistula repair cases and the two other regional hospitals involved in fistula repair only when visiting surgeons are available usually once a year.

Prolonged labour impact

In this study, factors affecting obstetric fistula repair failure showed that women who had labour for more than 24 hours were more likely (twice the chances) to have failed repair than those in labour for lesser than 24 hours. This finding is comparable to findings from Ethiopia Bahir-dar[27] and Rwanda.[25] This accounts for any form of delay in access to care, be it indecisions or delay in arrival at the facility, or delay in receiving quality care at the facility, resulting in increasing duration of labour and likelihood of obstructed labour. Prolonged labour, especially exceeding 24 hours, was associated with higher odds of poor-quality repair outcomes. The ischemic necrosis of soft tissues due to prolonged labour contributes to worsened tissue damage and scarring. Limited surgical facilities in resource-limited settings may result in more aggressive procedures, further elevating the risk of fistula development. Access to quality obstetric care, including catheterization, is imperative, especially in regions with limited specialized facilities

Access to antenatal care

Antenatal attendance of 75.5 % in this study is lower than the national data form MDHS 2015-16 at 95%. This population

with lower attendance rates may be more prone to obstetric complications. Quality obstetric care, encompassing antenatal care (ANC) and emergency obstetric surgeries, plays a crucial role in mitigating obstetric complications, including fistula development.[25] The ANC attendance rates in Malawi is documented at 95% by MDHS 2015 however this population was a high risk and lacked adequate antenatal care, coupled with health facility delivery rates, underscore the need for improved screening and follow-up, particularly for high-risk pregnancies. Identifying and supporting at-risk mothers during ANC and labour are pivotal in preventing obstructed labour, a primary cause of obstetric fistula. MDHS 2015,[35] highlighted the challenges faced in maternity care being difficulties in accessing money in 52.8%, distance to health facility in 55.6%, not wanting to go alone in 30%, at least one problem in accessing health care service in 72%. This demonstrates huge access problems at national level and even more to these group of women at high risk.

Clinical determinants of failure of repair

Further findings demonstrated that women with larger (>3 cm) fistula size had nearly two fold the odds of likely to have fistula repair failure .Similar findings have been supported in studies form Ethiopia,[27] Uganda,[36] and Democratic Republic of Congo.[24] Surgically this may be due to a large fistula being challenging to mobilise tissues or inadequate bladder tissues to achieve a tension free closure. Arising from this difficulty closure is encountered.[20,36]

Women who had Goh Type 3 fistulas were twice at risk of fistulae repair failure than women with Goh Type 1 fistula. This finding is supported by Ethiopian study findings from their Hamlin Fistula centre.[27] The reason being the closeness of the fistula to the urethra meatus and associated fibrosis, affects the urinary continence mechanism and leads to high chances of repair failure.

Furthermore this study reveals that women with a significant urethral damage were 2 times likely to experience fistulae repair failure .This finding is validated by findings in Ethiopian's Addis Ababa Hospital,[31] Democratic Republic of Congo,[37] Guinea[38] and Cameroon.[33] It's been suggested that with a damaged urethra length, becomes de-nerverted and shortened .This is witnessed where urethral fistula repair is found to be complex which results in patients becoming incontinent even after surgical repair as reported by Goh et al.[28,39] Waaldijk's classification emerged as a significant predictor of success rates, highlighting the importance of considering complexity and continence mechanism involvement in classifying fistula.

Post operative duration of an indwelling catheter beyond 14 days conferred and increased risk of 1.2 times of repair failure. This is also supported from publications from Ethiopia with more established fistula centres like the Hamlin Centre. The possible explanation is that urinary catheterization for over 14 days may be associated with "increased risk of pain, infection and formation of stones and erosion related catheter complications" emphasizing the need to adhere to the WHO post op catheter care following obstetric fistula repair. WHO recommends a short duration of bladder catheterization following obstetric fistula repair.[40]

Study Limitations

The study included a diverse population attending a public referral health facility in a developing country over ten years.

To date this is one of the largest retrospective series. Data as regards causes of incontinence after successful closure was not possible and this study reported the continence outcome on discharge.

CONCLUSIONS

In conclusion, this study showed decreasing magnitude of repair failure over a decade which were within WHO recommend rates. This demonstrates feasibility of successful fistula repair services with adequate resources in an established fistula repair centre.

Longer duration of labour, with delayed repair of the fistula, and scarred tissue, large fistula, prolonged indwelling catheter were significantly associated with repair failure. Addressing fistula burden in Malawi requires ongoing improvement in holistic access to comprehensive emergency obstetric care, increased access to quality, safe fistula repair services, training more surgeons, and community-level support on advocacy and education for early identification and referral of at-risk women.

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PART III: SYNTHESIS AND STRATEGIC RECOMMENDATIONS

CHAPTER 8: DISCUSSION

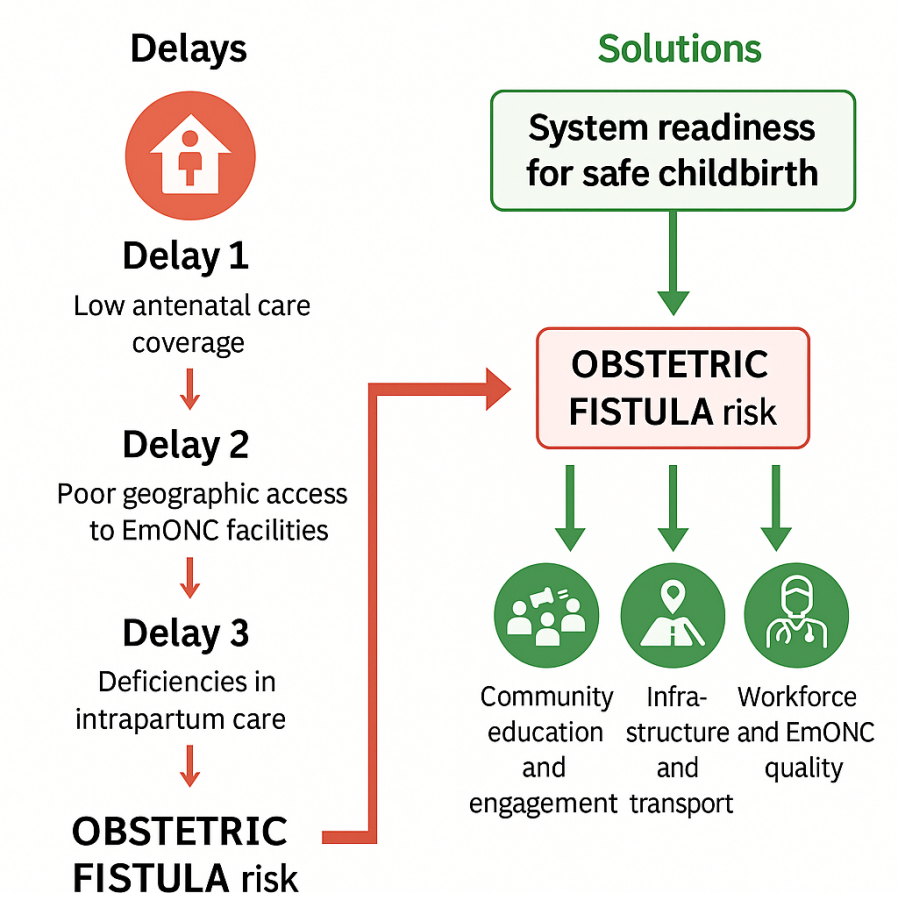
8.1 **Introduction**

Obstetric fistula is both a medical condition and a marker of health system failure, arising almost exclusively from obstructed labour in the absence of timely and adequate obstetric care. This discussion synthesizes the study's findings through the lens of the **Three Delays framework** – Delay 1: the decision to seek care, delay 2: reaching care, and Delay 3: receiving adequate care (Thaddeus & Maine, 1994) [1]. Organizing the evidence in this way highlights how individual, community, and system-level factors jointly contribute to fistula in Malawi, and it aligns the analysis with national and global strategies aimed at ending preventable maternal morbidity. The Three Delays model provides a unifying structure to integrate results from the Demographic and Health Survey (DHS) analysis, geospatial (GIS) modelling, clinical audit, qualitative reviews, and policy review. By contextualizing each "delay" within Malawi's policy framework – including the National Obstetric Fistula Strategy (2023–2030) and the National Surgical, Obstetric and Anesthesia Plan (NSOAP) – we link empirical findings to ongoing efforts and targets[2]. Globally, Malawi's commitment to the UNFPA **Campaign to End Fistula by 2030** parallels those of neighbouring countries; for example, Tanzania and Uganda have launched similar fistula eradication initiatives (Njeru, 2024)[3]. The discussion that follows uses regional comparisons to illustrate how Malawi's challenges and opportunities mirror broader trends in sub-Saharan Africa, while emphasizing what is unique to the Malawian context. Ultimately, addressing all three delays is critical for preventing new fistula cases and improving outcomes for women already affected, thereby advancing both national goals and international commitments to maternal health equity.

This diagram below synthesizes the findings from Chapters 5 (Delay 1: Community-level barriers), 6 (Delay 2: Geographic and access-related barriers), and 7 (Delay 3: Facility-level and clinical care constraints), mapping them along the Three Delays Model. On the left (in red) are the primary risk pathways leading to obstetric fistula—ranging from low antenatal coverage and sociocultural delays in care-seeking, to poor physical access to EmONC facilities, and ultimately to deficiencies in surgical capacity and intrapartum care quality. On the right (in green) are targeted health system interventions aligned with each delay: community education and engagement for Delay 1, infrastructure and transport solutions for Delay 2, and workforce, surgical readiness, and EmONC quality improvements for Delay 3. The convergence of these

solutions reflects a resilient health system that is not only responsive to emergencies but also equipped to prevent maternal morbidity, including fistula, through timely and equitable care.

Figure 18. ***Conceptual map illustrating the interplay between Delays 1, 2, and 3 in obstetric fistula, and the corresponding system-level interventions required to strengthen maternal health preparedness in Malawi.***



8.2 Delay 1: Decision to Seek Care

Delay 1 refers to the time taken for a woman and her family to recognize a problem and decide to seek medical care. For obstetric fistula – which typically develops after a traumatic, obstructed labour – this delay often begins long before labour, rooted in sociocultural and economic factors that influence whether and how women engage with maternal health services. Our findings, supported by other studies in Malawi, underscore that women's decisions around childbirth are constrained by poverty, limited education, and gender dynamics, which can conspire to delay seeking skilled care (Changole et al., 2018)[4]. In a qualitative study capturing Malawian women's pathways to fistula, participants described how **"poverty, illiteracy, …**

and lack of male involvement in childbirth" contributed to prolonged labour at home and late presentation to hospitals (Changole et al., 2018)[4]. Traditional norms often expect childbirth to be managed within the community; indeed, many women in rural Malawi initially labour with the help of traditional birth attendants (TBAs) or female relatives, only considering a health facility when complications become life-threatening. In such settings, the decision to seek care may not rest solely with the woman: mothers-in-law, husbands, or TBAs themselves commonly make or delay the decision to transfer to a clinic. If these decision-makers underestimate the danger or hold misconceptions (for example, believing obstructed labour is normal or caused by witchcraft), the woman can endure obstructed labour for days without medical intervention. Tragically, this scenario often leads to the death of the baby and leaves the mother with internal injuries that cause fistula.

Sociocultural Barriers

Stigma and fatalism surrounding obstetric fistula further impede care-seeking. Many women who develop fistula experience immediate social consequences – abandonment by husbands, ostracism by communities – which in turn breed shame and secrecy. Our clinical data showed an **average delay of 7.2 years from fistula onset to a woman's first presentation** at a fistula treatment center, a delay largely attributable to women hiding their condition due to embarrassment and fear of social rejection. This inaction is reinforced by the misconception that fistula might be a divine punishment or simply untreatable. In Malawi's conservative rural communities, a leaking woman is often considered "unclean" and may self-isolate, further delaying any attempt to seek help. Similar patterns are observed regionally: in Tanzania and Uganda, a 2019 study found that **more than half of women with fistula waited over a year before seeking treatment, citing fear, stigma, and lack of awareness about available care** (Njeru, 2024)[3]. These findings highlight that purely improving medical services will not eliminate fistula unless sociocultural barriers to utilization are also addressed.

Gender Roles and Decision-Making Power

Women's lack of autonomy and low male engagement in maternal health decisions are critical contributors to Delay 1. In Malawi, as in much of the region, husbands or elder family members often control when a woman goes to a hospital for childbirth. A study on male involvement in rural Malawi reported that traditional gender roles often **exclude men from participating in maternal health decisions**, leading to delayed permission or support for women to seek care when labour becomes complicated (Dral et al., 2024)[5]. Notably, greater **male partner support**

is linked to timely care: women whose husbands are informed and involved in birth plans are more likely to deliver in health facilities. Conversely, when men are disengaged or only belatedly convinced (for example, when a labour has already gone on for days), the window for preventing injury may have closed. The National Fistula Strategy explicitly calls for community education that targets men, emphasizing that they should be **"educated and involved in maternal health… to help make informed decisions when their spouses face complications"** (Ministry of Health [Malawi], 2023)[2]. Engaging men as partners in safe motherhood – through initiatives like spousal attendance of antenatal classes or community leaders championing facility delivery – can substantially reduce first-delay barriers.

Awareness and Antenatal Care (ANC) Utilization

Antenatal care serves as a preventative platform and an entry point into the formal health system; low ANC attendance is both a symptom and a cause of first-delay issues. Our spatial analysis found a strong inverse association between ANC coverage and fistula prevalence across districts: areas with the poorest ANC 4+ attendance had the highest fistula burdens. For example, districts like Mangochi and Machinga, which have some of the lowest ANC attendance rates (under 40% of women receiving at least four visits), also report fistula prevalence nearly double that of better-served urban districts. This correlation must be interpreted with caution – ANC attendance itself may not directly "prevent" a fistula the way a timely cesarean would, and the relationship is likely confounded by underlying factors (poverty, distance, education) that affect both ANC uptake and obstetric outcomes. Indeed, attending antenatal clinic is not a guarantee of safe delivery if the facility-based care is suboptimal. However, **ANC has an important indirect effect**: women who attend clinics during pregnancy receive health education (including recognition of danger signs), develop birth plans, and are more likely to opt for delivering in a facility with skilled attendants. In essence, low ANC coverage is a proxy indicator of communities where women are disconnected from the health system – due to cost, lack of information, or sparse services – and these are the same communities where obstetric emergencies like obstructed labour are most likely to lead to devastating outcomes. It is therefore appropriate to treat inadequate ANC utilization as a major risk factor or marker for fistula, while recognizing that the root causes are systemic. Our regression analysis confirmed this non-causal association: districts with higher rates of women lacking any skilled antenatal care had significantly higher odds of fistula, underscoring the need to improve ANC access as part of fistula prevention. Notably, Malawi's DHS data indicate progress in ANC coverage – an increase from ~51% to 62% of

women receiving at least four visits between 2015 and 2025 – yet this remains insufficient. Rural and hard-to-reach areas lag far behind national averages, with many pregnant women still citing **financial and geographic constraints** as reasons for not attending clinic. Over half of Malawian women who do not complete four ANC visits attribute it to cost or distance barriers, reflecting an interplay of Delay 1 and Delay 2 factors.

Addressing Delay 1 – Implications for Prevention

The findings point to several strategies to overcome the first delay. **Community education and engagement** are paramount. Women (and their families) need to recognize obstructed labour as an emergency that requires skilled medical intervention; this awareness can be fostered through village health talks, radio programs, and involving trusted community figures (such as traditional chiefs or healed fistula survivors) in advocacy. For instance, Malawi has begun using "fistula ambassadors" – women successfully repaired who return to their villages to destigmatize the condition and encourage others to seek care. Such peer education is vital to erode the fatalism and shame surrounding fistula. Additionally, **empowering girls and women** is a long-term preventive measure. Low female literacy and early marriage/pregnancy are known contributors to maternal complications. Ensuring girls stay in school and delaying first childbirth until physical maturity can significantly reduce obstructed labour risk. In alignment with this, qualitative evidence from Malawi recommends **"promoting girls' education to increase their financial autonomy and decision-making power"**, so that women are better equipped to make and act on health decisions (Changole et al., 2018)[4]. Economic empowerment of women (through microfinance, vocational training, etc.) can likewise mitigate poverty-related hesitancy in seeking care. **Male engagement programs** are another key intervention: by educating men about birth preparedness and danger signs, communities can leverage men's influence in a positive way (e.g. husbands arranging transport in advance, saving money for delivery, and supporting wives in early transfer if labour is prolonged). There is precedent in Malawi's health sector for successful male motivation campaigns – for example, in HIV prevention – which could be adapted to maternal health.

Finally, strengthening **antenatal care outreach** bridges knowledge and access gaps. Bringing ANC services closer to remote communities (via outreach clinics or mobile antenatal units) and providing incentives (such as transportation vouchers or small conditional cash transfers for completing ANC visits) can boost attendance among underserved populations. Community health workers and Health Surveillance Assistants (HSAs) play a pivotal role in bridging access gaps by providing follow-up to pregnant women, promoting early antenatal care (ANC)

booking, and reinforcing the importance of delivering at appropriately equipped health facilities. In addition to HSAs, Traditional Birth Attendants (TBAs)—often the first point of contact in rural and underserved communities—can be effectively integrated into the maternal health ecosystem. Within a structured and supervised framework, TBAs can support early pregnancy identification, refer high-risk cases to formal health facilities, and serve as liaisons to promote timely ANC engagement. While TBAs are not a substitute for skilled birth attendants, their community trust and embedded presence make them valuable partners in improving early referral pathways and reducing Delay 1 and Delay 2 in the continuum of care. Training, supervision, and formal referral protocols are essential to ensure that their involvement enhances, rather than compromises, maternal health outcomes.

In summary, reducing Delay 1 requires tackling deep-seated social determinants – poverty, gender inequality, and education – as well as implementing targeted health education. These efforts are explicitly recognized in Malawi's national policies. The National Obstetric Fistula Strategy 2023–2030 calls for multisectoral action to address community-level risk factors, and Malawi's Health Sector Strategic Plan III (2023–2030) emphasizes increasing **"demand for facility services"** through community mobilization and male involvement programs [2]. When women and families are empowered with knowledge, free from undue social pressures, and supported economically, they are far more likely to seek timely care – preventing obstetric catastrophes that lead to fistula in the first place.

8.3 Delay 2: Reaching Care in Time

Delay 2 encompasses the barriers that prevent a woman who has decided to seek care from reaching a facility promptly. In Malawi, geographic distance and transportation challenges are critical contributors to this delay, especially for rural women experiencing obstructed labour. Our GIS modelling and spatial analyses vividly demonstrated inequities in physical access to obstetric services, which directly translate into higher fistula risk. Simply put, when a woman in obstructed labour is many hours away from a functioning surgical facility, the likelihood that she will incur extensive tissue damage (and thus a fistula) increases exponentially with each passing hour of delay.

Geographical Barriers and Infrastructure

Malawi's topography and infrastructure impose severe hardships on pregnant women in remote areas. We identified several *hotspot* districts – notably Nsanje and Chikwawa in the Lower Shire Valley, and parts of Mangochi in the southeast – where women face travel times often

exceeding 3–4 hours to reach the nearest hospital with emergency obstetric capability. During the rainy season, these districts are prone to flooding that cuts off roads entirely. For a woman in obstructed labour, such delays can be deadly or disabling. Our data showed that in Mangochi (a district with sprawling lakeshore communities and challenging terrain), **health facility density is only ~6.7 facilities per 10,000 women of reproductive age, and fistula prevalence is about 0.7%** – nearly double the rate in Lilongwe City (0.4%), which has a density of 12.8 facilities per 10,000 women. This correlation between sparse local healthcare infrastructure and higher fistula incidence was consistent across the country, evidenced by a moderate but significant statistical relationship between facility accessibility and obstetric outcomes (Pearson $r \approx 0.53$). In other words, where it is physically *"too far to walk"* for timely obstetric care, women continue to suffer obstructed labours that result in fistula – reflecting the classic observation by Thaddeus and Maine (1994)[1] on geography as a determinant of maternal mortality.

Malawi is not alone in this challenge. Similar disparities appear across sub-Saharan Africa: research in Tanzania found that only around **20% of rural women live within a two-hour travel radius** of a facility offering surgical obstetric care (Ouma et al., 2018)[6]. In Ethiopia, fistula cases overwhelmingly originate in remote villages far from Addis Ababa, since fistula repair services (and, by extension, advanced obstetric care) are highly centralized in the capital. Nigeria shows a comparable pattern, with fistula repair centers clustered in a few cities, forcing many rural northern women to traverse great distances for treatment. These geographic inequalities underline a cruel paradox: the women who are most vulnerable to obstetric emergencies (often young, malnourished mothers in deep rural poverty) also face the greatest physical barriers in accessing the very care that could save their babies and themselves. Our study's Lorenz curve analysis quantified this inequity in Malawi: over **80% of all fistula surgeries were being performed in just 20% of districts** (mainly the urbanized ones), leaving vast rural areas with minimal local capacity. Indeed, we found that more than four-fifths of fistula repairs occur in the two main urban centers (Lilongwe and Blantyre). The corollary is that a rural Malawian woman must often travel to these cities to get definitive care – a journey that is not only long and costly, but for an obstetric emergency, frequently too late.

Transportation and Referral Challenges

Even when a woman resolves to go to the hospital, practical obstacles in transportation can introduce life-threatening delays. In Malawi's rural villages, ambulance services are scarce.

Families often rely on bicycle ambulances, ox-carts, or hiring private vehicles if available – all of which cost time. The **cost of transport** itself is a major barrier: a family living on subsistence farming may not have the cash for fuel or fares, leading to dangerous procrastination as they try to mobilize funds. In Malawi's health system, not every health center can perform a C-section (many are health posts or small clinics), so a woman might first go to the nearest clinic, only to be put in an ambulance to the district hospital. That handoff can be slow if ambulances are not immediately available or if communication is poor. Unfortunately, accounts of ambulances arriving without fuel, or referral letters being written but the patient left waiting, are not uncommon in low-resource settings. Each additional hour spent in transit or referral is an hour that the unborn baby is compressing the mother's tissues, risking fistula formation.

Our findings highlight that economic constraints are intertwined with transport delays. Over half of women who did not give birth in a facility cited transport cost as a deterrent (a statistic mirrored in reasons for skipping ANC). Poverty thus literally slows the journey to care – a Delay 2 factor superimposed on Delay 1. A poignant regional example comes from Uganda: one woman endured four days of labour and multiple transfers (from home to a health center by bicycle, then to a hospital by ambulance) before receiving a cesarean – tragically too late to save her baby or prevent a fistula (Fallon, 2014)[7]. Her story of **"seeing four dawns before delivery"** underscores how inadequate transport and referral networks turn treatable complications into devastating injuries. The Ugandan health ministry estimates that roughly **2,000 new fistula cases occur each year and about 200,000 women live with the condition nationally**, largely because many cannot reach or do not receive timely obstetric care (Fallon, 2014). Even when countries provide free emergency surgery (as Uganda and Malawi do), it is meaningless if a woman cannot physically get to the operating table in time.

Reducing Delay 2 – Decentralization and System Improvements

Tackling the second delay requires improving physical access to care through **decentralization of services, better transport infrastructure, and referral system strengthening**. Decentralization means bringing life-saving obstetric functions closer to where women live. Our study strongly advocates establishing additional emergency obstetric and fistula care centers in high-need regions. The NSOAP for Malawi recognizes this, aiming to ensure that each district has at least basic surgical capacity. In practical terms, **upgrading select district hospitals or health centers to provide 24/7 comprehensive emergency obstetric care**

(CEmOC) – including capability for cesarean sections and newborn care – is essential. If women can access a C-section within, say, 2 hours of onset of obstructed labour, fistula can be averted in nearly all cases. Currently, Malawi's national C-section rate is only about 5–6%, roughly half the minimum level (10–15%) expected to meet population obstetric needs. This indicates a substantial gap in service availability (and possibly utilization). Bringing C-section services closer to underserved communities (and ensuring they are functional with staff and supplies) will directly reduce both maternal mortality and the incidence of fistula.

One immediate intervention is establishing **maternity waiting homes** near hospitals. These provide lodging for women in late pregnancy who live far away, so that when labour starts, they are already near a facility. Maternity waiting shelters have had success in parts of Malawi and neighbouring countries, effectively bypassing the transport delay for high-risk or distant mothers. Expansion of such models, as well as **transportation support programs** (like dedicated ambulance services or community transport schemes), is recommended. For example, some districts have introduced bicycle ambulance networks or community emergency transport funds where villagers collectively maintain a bicycle or motorbike for maternal emergencies. Additionally, **road infrastructure investments** – while outside the health sector per se – play a huge role. Simple improvements like grading dirt roads or building footbridges over rivers can cut hours off travel time in remote areas. These are long-term developments, but health planners can collaborate with other sectors to prioritize routes that connect high- risk- maternal communities to health facilities.

The referral system needs organizational strengthening. This includes training health workers at peripheral clinics to recognize obstructed labor early and refer without delay and ensuring that communication (via radio or mobile phone) to call ambulances is reliable. Creative solutions are being tried in the region: "In Tanzania, a GIS-optimized referral network was developed to allocate ambulances efficiently and reduce transport times for obstetric emergencies". That initiative mapped health facilities and roads to simulate the fastest routes and best placement of emergency transport, resulting in measurably quicker transfers. Malawi could adopt similar innovations – for instance, positioning motorcycle ambulances in villages that can traverse rough terrain quickly or using mobile phone apps for community health workers to summon transport from the nearest hub. The NSOAP calls for achieving the global target of **80% coverage of essential surgery within 2 hours distance**; applying this to obstetric care means vastly expanding and equitably distributing emergency obstetric services (Meara et al., 2015)[8].

Cost barriers can be mitigated by health financing measures. Although Malawi offers free maternal healthcare in public facilities, indirect costs (transport, food for accompanying family, etc.) often burden families. Implementing or scaling up **transport voucher schemes** (where pregnant women receive a voucher or cash specifically for travel to the facility) could remove the financial hesitation. Such schemes have been piloted in some low-income settings with success in increasing facility deliveries. Likewise, community emergency savings funds or micro-insurance can help families cover sudden transport needs without catastrophic expenditure.

In summary, reducing Delay 2 is about ensuring **accessibility**: physically, financially, and logistically. The National Obstetric Fistula Strategy and HSSP III both emphasize the need to **"decentralize fistula repair services through regional centres and mobile surgical units"**, reflecting a commitment to bring care closer to those who need it. Indeed, mobile outreach surgical camps for fistula have been used in Malawi (surgeons from the Bwaila center travel periodically to provincial hospitals). While helpful for clearing some backlog, these are episodic; a more permanent presence of qualified staff in the provinces is needed. Experience from Ethiopia illustrates the impact of decentralization: Ethiopia established satellite fistula centers outside the capital and deployed teams to rural areas, which has improved access and reduced travel burdens for patients. Malawi can learn from and expand on these models, leveraging our GIS data to identify priority locations for new services. If a woman can reach skilled care promptly when labour complications arise, the injury that causes fistula can be prevented. Thus, achieving universal access to emergency obstetric care is a linchpin in Malawi's quest to eliminate obstetric fistula by 2030 – a goal currently out of reach without significant improvements in overcoming the second delay.

8.4 Delay 3: Receiving Adequate Care

Delay 3 refers to the barriers women face in obtaining prompt, appropriate, and high-quality care after arriving at a health facility. In the context of obstetric fistula, this delay reflects both failures in intrapartum management—where timely interventions could have prevented injury—and deficiencies in the subsequent treatment and rehabilitation of affected women. Our findings indicate that, even when women reach care, systemic weaknesses in staffing, readiness, and clinical quality contribute to preventable morbidity, prolonged suffering, and, in some cases, irreversible harm.

Quality of Intrapartum Care and Emergency Response.

Neglected obstructed labour remains the leading cause of fistula in Malawi, yet qualitative studies highlight that many women experience further delays after facility arrival. Changole et al. (2018)[3] documented that "women often faced shortages of skilled staff, absence of surgical teams during off-hours, slow decision-to-incision times for caesarean section, and unavailability of essential resources such as blood for transfusion". In such contexts, a potentially treatable complication can escalate into a maternal death or a severe morbidity such as fistula. The low national caesarean section (C-section) rate of 5–6%—substantially below the WHO-recommended 10–15%—reflects both first- and second-delay barriers but also indicates significant facility-level capacity limitations. While some women never arrive at a facility, others arrive but cannot access surgery due to a lack of available surgeons, anaesthetists, functioning theatres, or critical supplies. This gap is particularly consequential given that obstructed labour with uterine rupture or sepsis remains a leading cause of maternal mortality in Malawi, and fistula represents the injury of those who survive such intrapartum mismanagement.

While most fistula cases in Malawi are attributable to ischaemic injury, operative injury remains an important, avoidable cause. "In a previous study at Bwaila Fistula Care Centre, Kopp et al. (2016)[9] found that 26.3% of vesicovaginal fistula repairs were "high" fistulas—located at the vaginal apex, cervix, or uterus—more commonly associated with caesarean section or hysterectomy than with pressure necrosis. Women with high fistulas were significantly more likely to be multiparous, deliver a liveborn infant, and have undergone surgery at the time of fistula formation (aOR = 3.88; 95% CI: 2.27–6.63)". These findings underscore that Delay 3 includes both timeliness—the speed at which life-saving interventions such as C-section are initiated—and safety—the technical quality and intraoperative skill with which such interventions are performed.

"Iatrogenic injuries are more frequent in health systems where surgical workload has expanded without proportional investment in competency-based training, structured mentorship, and adherence to surgical safety protocols" (Ngongo et al., 2022). In Malawi, decentralisation of emergency obstetric surgery to district-level hospitals has improved geographic access but has, in some cases, heightened the risk of operative injury when not accompanied by robust workforce preparation, reliable supply chains, and theatre readiness. These risks are compounded by the absence of systematic intraoperative injury recognition, weak postoperative follow-up, and limited opportunities for continuous surgical audit.

Addressing Delay 3 therefore requires a dual focus on **emergency readiness**—ensuring all facilities designated for comprehensive emergency obstetric care (CEmOC) can provide timely, 24/7 caesarean section and transfusion services—and **surgical safety**—strengthening technical capacity, embedding continuous mentorship, and enforcing adherence to evidence-based surgical protocols. National strategies such as the NSOAP and the Health Sector Strategic Plan already call for scaling up surgical obstetric services and upgrading infrastructure to meet EmOC signal functions. Achieving these goals will require integrated measures including (i) adequate staffing with trained surgical teams on-call at all district hospitals, (ii) rapid decision-making protocols (e.g., partograph monitoring, criteria for timely intervention), (iii) routine emergency drills to reduce response times, and (iv) reliable access to critical resources such as blood and sterile equipment. Without these systemic improvements, the persistence of facility-level delays will continue to undermine fistula prevention and delay effective surgical repair for those already affected.

Health Workforce and Fistula Treatment Capacity

Our clinical audit and policy review highlighted significant workforce gaps impacting both preventive and curative obstetric care. Malawi has a dearth of specialist obstetricians and fistula surgeons, especially outside the capital. The Bwaila Fistula Center in Lilongwe – the main referral center – has trained over 70 clinicians in fistula repair techniques over the years, yet fewer than 10 are actively performing surgeries in-country, and only **three surgeons are based full-time in Lilongwe for fistula care**. The rest of the trained providers either left, focus on other duties, or are constrained to doing only screenings due to lack of operating room opportunities. This reflects issues of **retention and skills utilization**. Frequent rotation and attrition (some trained clinical officers move to other roles or the private sector) mean that building and maintaining surgical expertise is difficult. Outside the specialized center, many district hospitals have *no* staff confident to repair a fistula, and some do not even consistently have a surgeon to perform basic obstetric surgeries. The result is that fistula repair services are heavily **centralized**, with roughly 400 surgeries per year being done at Bwaila and only sporadic cases at a few other sites. As noted earlier, this centralization leaves most patients in rural areas without local access, contributing to the treatment gap of an estimated 13,000–20,000 women living with fistula in Malawi who have yet to receive surgery [2].

The National Fistula Strategy recognizes these workforce issues. It has initiated training programs – for example, from 2017 to 2022, the Ministry of Health trained **12 clinical officers**

and 9 doctors/registrars in fistula repair, and over 100 nurses/midwives in fistula care as part of a strategic push (but hasn't translated to adequate fistula care services)[2]. While a positive step, these numbers are still far short of what is needed to staff all regions. Moreover, without a structured career path or incentives, maintaining these skills is hard; many trained individuals revert to general duties in obstetrics/gynaecology without routinely practicing fistula surgery, leading to skill decay. **Task-shifting and task-sharing** are likely necessary solutions: training more mid-level providers (clinical officers or nurse-midwife specialists) to perform basic fistula repairs and emergency obstetric surgeries could expand capacity in rural areas. This approach has been piloted in Tanzania and Uganda, where non-physician clinicians have been successfully performing C-sections and even fistula repairs in some cases. Our review of regional initiatives found that Tanzania and Uganda have implemented competency-based training and mentorship programs to enable such task-shifting and have integrated fistula modules into postgraduate obstetrics curricula to ensure new doctors graduate with these skills. Malawi could greatly benefit from similar integration – making fistula prevention and repair a standard part of obstetric training and certification. Additionally, creating incentives for specialists to serve in high-burden rural districts is crucial. Our results support introducing **"rural allowance" or other financial incentives** to attract and retain surgical talent in underserved areas. For instance, offering salary top-ups, housing, or career advancement opportunities for those who commit to work in districts like Mangochi or Machinga might help prevent the current drift of skilled personnel toward cities or abroad.

Another dimension of third-delay care is the capacity to manage complications and follow-up. Even after a fistula is repaired, women require good post-operative care to heal and rehabilitate. Yet we found that only **~36% of women returned for post-surgery follow-up** at the fistula center. Reasons include the same transport and cost issues (traveling back for a check-up is difficult for rural patients) and a cultural perception that once "repaired" there is no need for further medical visits. This gap means that complications like residual incontinence or new pregnancies are not being monitored. It also indicates a missed opportunity for counseling on future maternity plans (e.g. advising cesarean in a subsequent pregnancy to protect the repair). The Fistula Strategy, in collaboration with the Ministry of Gender, has piloted **rehabilitation and reintegration programs** – such as income-generating skills training at Bwaila's on-site hostel and the use of fistula survivors as community advocates. However, the strategy notes limited coordination between health services and social support programs to date. Strengthening this collaboration would improve continuity of care. For example, after repair, patients could be linked with local social workers or support groups (some NGOs in Malawi

facilitate such networks) to assist with reintegration, thereby encouraging follow-up.

Addressing Delay 3 – Health System Strengthening

The third delay highlights the need for broad health system improvements – essentially ensuring that **"getting to the hospital" equals "getting the life-saving care and quality treatment needed."** Several policy and strategic implications flow from our findings:

Improve Emergency Obstetric Care Nationwide: To prevent fistula at its source, every labouring woman who develops complications must receive timely, adequate care. This calls for upgrading infrastructure (operating theatres, blood banks, etc.) and ensuring round-the-clock availability of CEmOC in all districts. It also means increasing the national surgical output – Malawi likely needs to at least double its caesarean delivery rate to meet true demand. However, expanding access without parallel improvements in surgical safety can inadvertently increase harm. Evidence from prior Malawian research (Kopp et al., 2016) shows that over a quarter of vesicovaginal fistulas repaired at Bwaila Fistula Care Centre were "high" fistulas, often linked to operative injury rather than ischaemic necrosis from obstructed labour. These findings underscore that obstetric surgery scale-up must be paired with competency-based training, structured mentorship, adherence to safety protocols, and reliable availability of critical resources such as blood for transfusion. Achieving this is integral to Malawi's commitment to SDG 3.1 (reducing maternal mortality) and directly prevents fistulas. The government's adoption of the NSOAP is a step in this direction; our results urge prioritizing obstetric surgery within NSOAP implementation. For example, tracking the WHO indicator of 2-hour access to surgery in maternal cases, and working to improve it (Malawi could adapt Tanzania's GIS planning methods to identify where to add services).

Expand and Equitably Distribute the Health Workforce: Without skilled providers, even well-equipped facilities are of little use. Policymakers should continue and amplify efforts to train specialist teams – not only fistula surgeons but also anesthetists and midwives skilled in managing obstructed labour. **Retention strategies** are crucial: the government might consider bonding schemes (requiring a period of service in-country after training) or enhanced career pathways for those who specialize in maternal health in rural areas. The idea of "regional centres of excellence" for fistula care is valuable: for instance, establishing at least one fistula surgery team in the Northern Region and one in the Southern Region, rather than all teams being in the Central Region. Our GIS workforce analysis suggests deploying surgeons to high-prevalence districts – essentially matching human resources to disease burden. Telemedicine

and e-learning can support these remote teams by connecting them with international experts for ongoing mentorship (something already practiced informally at Bwaila with visiting surgeons). The Fistula Strategy's mention of integrating fistula repair into medical curricula and using technologies like tele-mentoring is in line with global recommendations; implementing these will gradually build a sustainable pipeline of experts.

Enhance Quality and Accountability: Healthcare quality improvement programs should include specific metrics for obstetric care – for example, audits of all obstructed labour cases or "near-miss" reviews for any fistula cases. If a woman arrives at a hospital but still ends up with a fistula, that case should be reviewed to identify system failings (e.g. Was there a delay in performing the C-section? Was there an issue with the clinical decision-making or resources?). Such accountability can drive changes like better supervision or protocol adherence. Additionally, **clinical guidelines** should be reinforced: routine use of the partograph to track labour progress and clear criteria for timely intervention. Training midwives and doctors in fistula prevention – essentially emphasizing that a labour should *not* be allowed to continue beyond a certain point without action – is a preventative mindset to instil.

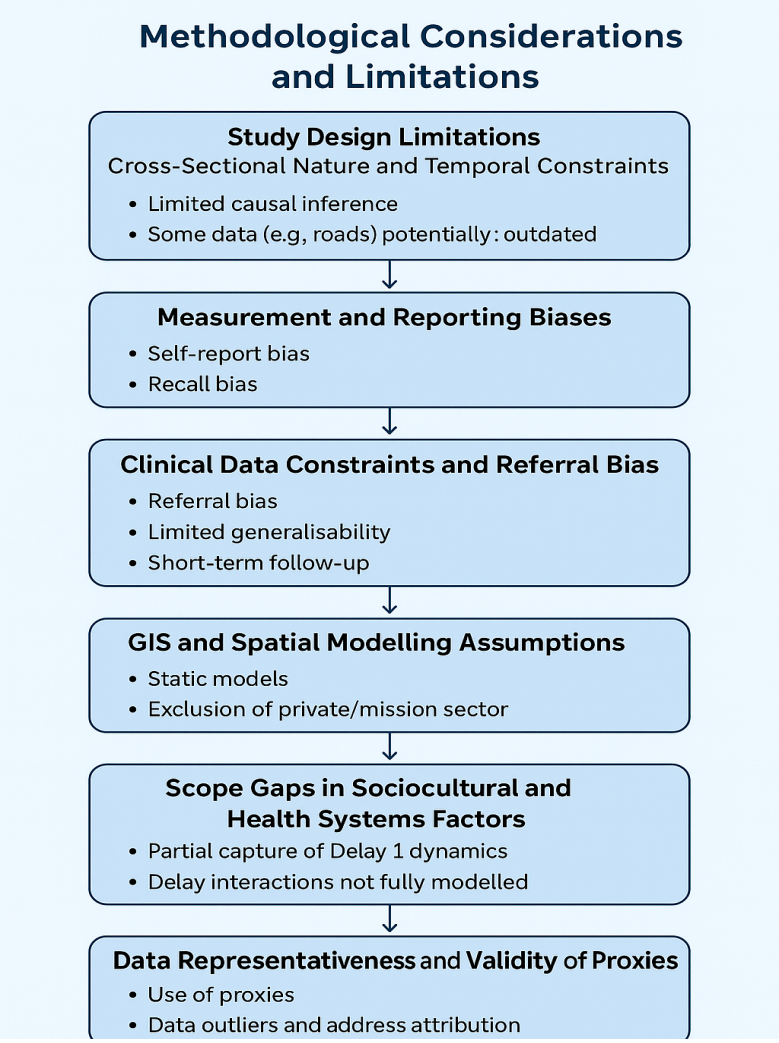
Comprehensive Post-Fistula Care: For women who do suffer fistula, receiving adequate care goes beyond surgery. A holistic approach involves psychosocial support, physiotherapy (for injuries like foot-drop from nerve damage), and socio-economic reintegration. The Malawi Fistula Strategy and partners (like UNFPA and various NGOs) have begun such programs, as seen in the "fistula village" concept at Bwaila and the fostering of support groups. Scaling these up nationally would ensure that *receiving care* means not just a surgical repair, but restoration of dignity and functionality. For example, Tanzania's **Mabinti Centre** provides vocational training to fistula survivors to help them rebuild their lives (Njeru, 2024)[3]. Similar initiatives could be regionalized in Malawi, possibly through collaboration with the Ministry of Gender and community development projects. Importantly, improving follow-up (perhaps via mobile health – e.g. midwives making follow-up calls, or community nurses visiting patients) will improve long-term outcomes. Our findings suggest using mHealth tracking for operated patients to remind them of follow-up appointments and to monitor any continence issues or needs for second surgeries. This can significantly enhance the **quality of care** they receive in the long run.

In conclusion of the Three Delays analysis, it is evident that obstetric fistula in Malawi is not merely a clinical issue but a symptom of broader health system and societal shortcomings. Delay 1 factors ensure that many labours start off in suboptimal conditions; Delay 2 barriers mean complications are not managed in time; Delay 3 failings allow injuries to occur even under medical supervision and then limit the care available to those injured. Encouragingly, however, each of these delays also represents a **point of intervention**. The government and stakeholders have levers to pull – from community education and female empowerment (to tackle Delay 1) to infrastructure and referral improvements (Delay 2), to health system strengthening (Delay 3). The National Obstetric Fistula Strategy 2023–2030 explicitly addresses all three levels: community prevention, service accessibility, and quality treatment. Our study's findings reinforce and provide data-driven nuance to that strategy, identifying where efforts are most urgently needed (for example, targeting high-prevalence, low-access rural districts for interventions). In the next sections, we reflect on the limitations of our data and analyses and discuss the broader implications of these findings for policy, systems, and research.

8.5 Methodological Considerations and Limitations

Understanding the methodological strengths and limitations of this study is essential for interpreting its findings with the appropriate degree of caution and nuance. Although the study employed a robust mixed-methods approach—integrating geospatial modelling, clinical audit data, and national household survey analysis—each data stream brought inherent constraints. These limitations, which are critical for framing the validity and generalizability of results, are thematically summarized in **Figure 19** below. The diagram outlines five key domains of potential bias and methodological challenges: *(1) Cross-Sectional and Secondary Data Limitations; (2) Reporting and Recall Bias; (3) Clinical Audit Limitations; (4) Geospatial Modelling Constraints; and (5) Sociocultural and Unmeasured Factors*.

*Figure 19**Thematic Overview of Methodological Limitations in the Study of Obstetric Fistula in Malawi***



Following this visual summary, the accompanying narrative provides a more detailed critical reflection on each limitation category—offering context, implications, and potential mitigation strategies.

1. Study Design Limitations: Cross-sectional Nature and Temporal Constraints

This research is largely based on cross-sectional data, including the 2015–16 and 2024–25 Malawi DHS, which inherently limits causal inference. While associations—such as the link between low ANC coverage and higher estimated fistula burden—can be identified, the temporal sequencing of these events cannot be conclusively established. Furthermore, although the study incorporated more recent surveys where available, certain components (e.g., road

networks, service availability) may have changed by the time of analysis, thus affecting the precision of spatial models.

2. Measurement and Reporting Biases

- **Self-report Bias:** Fistula prevalence data from DHS relies on self-reported symptoms (e.g., constant leakage post-delivery), introducing possible misclassification. Stigma and misunderstanding of symptoms may lead to underreporting or, conversely, overreporting of non-fistulous incontinence.
- **Recall Bias:** Both quantitative (DHS) and qualitative components are subject to memory decay and post-hoc rationalisation. Many interviewees described obstetric events from several years prior, which may affect the accuracy of accounts concerning Delay 1 and Delay 2 experiences.

3. Clinical Data Constraints and Referral Bias

The surgical audit was conducted exclusively at Bwaila Fistula Centre—a high-volume national referral facility. This may not represent the full national case spectrum due to:

- **Referral Bias:** Only women able to travel or be referred to Bwaila were included, excluding those who died before treatment or could not access care.
- **Limited Generalisability:** The observed 92% anatomical closure success rate and 2.6% immediate postoperative incontinence may not reflect outcomes at lower-level hospitals where surgical expertise and post-op care vary significantly.
- **Short-Term Follow-up:** Although 36% returned for post-op review, long-term outcomes (continence, reintegration) were not captured systematically, which limits assessment of sustained treatment success.

4. GIS and Spatial Modelling Assumptions

While GIS provided valuable insights into travel-time inequities and facility accessibility:

- **Static Models:** The travel-time models were based on static road and facility data and did not incorporate seasonal changes (e.g., flooding) that drastically affect accessibility in regions like Nsanje or Chikwawa during the rainy season.

- **Exclusion of Private/Mission Sector:** Access through CHAM or private facilities was not comprehensively mapped, which may result in underestimation of actual care options in some districts.

5. Scope Gaps in Sociocultural and Health Systems Factors

- **Partial Capture of Delay 1 Dynamics:** Although qualitative data addressed stigma, marital breakdown, and traditional beliefs, these were not quantified at population level. Key social determinants thus remain under-measured.
- **Delay Interactions Not Fully Modelled:** The Three Delays often interact—e.g., geographic isolation (Delay 2) exacerbates Delay 1 barriers—but for analytical clarity, this study examined each delay sequentially. A more dynamic systems-thinking model could be explored in future work.

6. Data Representativeness and Validity of Proxies

- **Use of Proxies:** ANC coverage and facility density were used as proxies for system readiness and access. While informative, these metrics cannot capture care quality or timeliness.
- **Data Outliers and Address Attribution:** Some estimated burdens in urban districts (e.g., Lilongwe City) may reflect referral clustering rather than local incidence due to patient address attribution near Bwaila Centre.

Despite these limitations, the triangulation of DHS data, spatial analysis, and surgical audit provides a credible and novel contribution to understanding fistula in Malawi. The study's insights are best interpreted as system-level signals rather than precise epidemiological estimates. Future longitudinal or cohort studies, enhanced by the latest DHS data and digital facility registries, could refine these models, and expand on the sociocultural determinants using mixed methods at scale.

8.6 Implications for Policy and Health Systems

Policy and Strategic Implications

Our findings carry significant implications for national policy and health system planning in Malawi. The persistent gaps identified across all three delays indicate that achieving targets like the **eradication of fistula by 2030** will require intensified efforts and perhaps a revision

of timelines. Indeed, based on current trajectories of improvement (e.g. the slow rise in ANC coverage and the modest expansion of repair services), a more realistic timeline for eliminating obstetric fistula in Malawi may extend beyond 2050 absent major interventions. This is sobering, yet it can also motivate policymakers to accelerate action. The National Obstetric Fistula Strategy 2023–2030 should be fully funded and operationalized, and our analysis provides evidence to prioritize its components. For example, the strategy's call for **"decentralizing fistula repair services by establishing regional repair hubs and mobile surgical units"** is strongly supported by our spatial findings – without decentralization, rural women will remain underserved. The Ministry of Health can use maps and data from this research to identify high-incidence districts like Mangochi, Chikwawa, and Nsanje as pilot sites for regional fistula centers or more frequent outreach repair camps. Additionally, the strategy's emphasis on **community engagement and male involvement** aligns with our Delay 1 conclusions; thus, inter-ministerial collaboration (e.g., Ministry of Health with Ministry of Community Development and Gender) should be bolstered to roll out mass education campaigns about maternal health and fistula prevention. Engaging traditional leaders and local influencers as champions (as has been done for HIV and child health in Malawi) could change social norms around childbirth and early marriage, gradually reducing the first-delay barriers.

Our study also underscores the need to integrate fistula prevention and treatment into broader frameworks like the Health Sector Strategic Plan (HSSP III) and the NSOAP. The NSOAP, for instance, is not just about surgeons and operations in the abstract – it should explicitly track obstetric surgical capacity, given that obstetric emergencies are a leading cause of surgical burden in Malawi. NSOAP implementation could include benchmarks such as: every district hospital to have at least one functional operating theatre and surgical team by year X; increase the number of C-sections performed (and by extension the proportion of obstructed labours adequately managed) by Y%. These should be monitored as key performance indicators. Aligning with global initiatives, Malawi's efforts feed into the **Global Surgery 2030** targets and the SDG indicators for access to emergency care (Meara et al., 2015)[8]. Furthermore, achieving SDG 3.1 (reducing maternal mortality) and SDG 3.8 (universal health coverage) will inherently cover the issue of fistula, since fistula incidence drops to essentially zero in settings where maternal health systems function effectively for all. There is also a strong gender equity component (SDG 5) – eliminating fistula is part of enabling women to live healthy, productive lives. International partners (UNFPA, WHO, NGOs) working on maternal health in Malawi can take these findings as a call to double down support for things like ambulance networks,

fistula camp funding, and community education, ensuring these initiatives are sustained and scaled.

Regionally, Malawi can share and learn from neighbors. For example, **Uganda's experience** shows the importance of national ownership and routine services: Uganda performs over 1,500 fistula repairs annually free of charge, yet still struggles with a backlog of tens of thousands of cases (Fallon, 2014; Njeru, 2024)[3,7]. This indicates that while surgical capacity must increase, prevention is paramount to avoid an ever-growing caseload. Conversely, **Tanzania's approach** of combining prevention (through maternal health improvements) with innovative rehabilitation (like the Mabinti Centre training for survivors) provides a holistic model for fistula care (Njeru, 2024)[3]. Cross-border knowledge exchange (through East African maternal health networks or the International Obstetric Fistula Working Group) could be beneficial – e.g., sending Malawian trainees to the specialized Addis Ababa Fistula Hospital in Ethiopia for mentorship, or adopting Kenya's practice of using survivor advocacy groups to find and support hidden cases. Such policy synergies can accelerate progress.

Health Systems Strengthening

The critical reflections on delays point to broader health system strengthening needs. Improving health infrastructure (more facilities, better-equipped facilities) in rural Malawi has a cost but yields multifaceted benefits: not only would fistula incidence decrease, but maternal mortality would drop, and likely neonatal outcomes would improve. Investments in roads and communication technology also serve multiple purposes beyond health, but in this context, their health impact is tangible. Strengthening the health workforce is arguably the linchpin – without human resources, bricks and mortar mean little. Thus, initiatives like the recent increase in Malawi's health budget allocation for hiring healthcare workers should continue, with a focus on training specialists in obstetrics and gynaecology, anaesthesiology, and reconstructive surgery. The creation of a fistula surgical fellowship or centre of excellence in Malawi could be considered to institutionalise the training of surgeons in this field (possibly in collaboration with universities and international experts). At the community level, expanding the role of frontline workers (HSAs, community midwives) in maternal health can bridge the gap between households and facilities, ensuring birth preparedness and timely referrals. Ultimately, preventing obstetric fistula at scale will require a dual commitment: expanding access to emergency obstetric services while simultaneously raising the quality and safety of surgical care, so that lifesaving interventions do not themselves become a source of harm (Kopp

et al., 2016; Ngongo et al., 2022).

Another systemic implication is the importance of **data and monitoring**. This research demonstrated the value of mapping and analyzing data to find gaps. The Ministry of Health should strengthen its health information systems to routinely capture indicators related to obstetric fistula – for example, adding fistula surveillance to maternal death audits, or tracking how many obstetric surgeries are done versus how many are needed. Regular national surveys (DHS or others) that include fistula-related questions (as Malawi did in 2015–16 and plans to in 2025) should continue, to measure prevalence trends. If possible, community-based studies to estimate incidence (new cases per year) would be useful for planning and evaluation.

In addition, as Malawi works towards the 2030 goal, **monitoring and evaluation research** should accompany program roll-out. If the Fistula Strategy is implementing new training and outreach initiatives, researchers should evaluate these efforts in real time (process evaluations, coverage assessments, etc.) to inform course corrections.

Overall, the multi-faceted nature of obstetric fistula – spanning clinical practice, geography, and socio-cultural context – means that no single intervention will suffice. A comprehensive approach addressing all three delays is imperative. This research provides an evidence-based foundation for such an approach, but continued inquiry and innovation will be needed to ultimately end obstetric fistula in Malawi.

Table 8. ***Summary of Integrated Findings Across the Three Delays***

Delay & Focus	**Key Barriers/Factors Identified**	**Consequences for Fistula Risk**	**Opportunities for Intervention**
Delay 1: Decision to Seek Care	– **Sociocultural factors:** Stigma of fistula; low status of women; **Knowledge gaps:** Low awareness of danger signs; if reliance TBAs. **Economic factors:** Poverty and costs (clinic fees, transport) deter ANC and early care-seeking.	– Obstructed labour at home due to delayed decision-making. Late presentation to hospital. Women endure obstructed labour without intervention; neonatal deaths and internal injuries occur. Average ~7-year delay from fistula	– **Community education:** Campaigns to recognize obstructed labour as emergency; use fistula survivors as "ambassadors." **Female empowerment:** Improve girls' education and delay early marriages to reduce risk; economic support for pregnant women. **Male involvement:** Engage men in birth preparedness (spousal ANC attendance, male champions) to support timely

	Low ANC utilization: Proxy for disconnection from health system; only 51–62% complete ANC 4+ visits (2015–2025).	onset to seeking treatment.	care-seeking. **Strengthen ANC outreach:** Mobile clinics and incentives (e.g. travel vouchers) to increase ANC attendance and early risk identification.
Delay 2: Reaching Care	– **Geographic barriers:** Long distance to nearest CEmOC facility in many rural districts; poor road infrastructure (flood-prone areas cut off seasonally). **Transportation gaps:** Few ambulances; costly transport (many rely on ox-carts/bicycles). **Referral system weaknesses:** Lower-level clinics lack surgical capacity, causing secondary delays during transfers; communication issues for calling ambulances.	– Inability to reach emergency obstetric care in time; labour continues unrelieved for hours or days. Higher fistula incidence in remote areas (e.g. fistula prevalence ~0.7% in low-access districts vs. 0.4% in cities). Urban–ruraldisparity: ~80% of fistula surgeries occur in just 2 urban centers, so rural women face delayed or no treatment. Some women never reach any facility or arrive when it is too late to save the baby or prevent injury.	– **Decentralize services:** Establish regional fistula repair centers and upgrade district hospitals for 24/7 cesarean capability (bring care closer to high-need areas). **Improve transport:** Invest in ambulance fleets, community transport schemes (e.g. bicycle or motorcycle ambulances), and maternity waiting homes near hospitals for at-risk mothers. **Strengthen referrals:** Train staff to promptly recognize complications and refer; implement reliable communication (radio/phone) and ambulance dispatch systems (potentially GIS-optimized). **Financial support:** Provide transport vouchers or emergency funds to ensure cost is not a barrier to reaching care.
Delay 3: Adequate Care at Facility	– **Quality of care issues:** Delays in performing C-sections after arrival (due to no surgeon at night, slow decision-making, or lack of bloodbanks & emergency supplies); **Resource shortages:** Insufficient numbers of trained	– Even at facilities, women may not get timely intervention, leading to fistula formation under care (a "third delay" failure). Low national C-section rate (~5%) post-surgery outcomes suboptimal: some women develop residual incontinence or have unaddressed	– **Strengthen EmOC quality:** Ensure 24/7 surgical teams in all district hospitals; improve protocols (use of partograph, emergency drills) for rapid response to obstructed labour. **Expand workforce:** Train and **retain** more specialists (e.g. incentives for doctors to serve in rural areas); adopt task-shifting by empowering clinical officers/midwives to perform basic surgeries; create a fistula surgery fellowship program for capacity-building.

	fistula surgeons (only ~3 full-time fistula surgeons in country); low incentives. **Service centralization:** Fistula repairs mostly at one center (Bwaila) in Lilongwe; limited capacity elsewhere. **Follow-up gaps:** Only 36% of women return for post-op review; weak integration of medical and social support services for recovered patients.	needs due to lack of follow-up and rehabilitation.	**Resource investment:** Upgrade operating theaters, improve /establish blood banks, and stock essential supplies in peripheral hospitals; leverage telemedicine for specialist support in remote surgeries. **Accountability:** Conduct audits of any fistula cases or maternal deaths to identify system failures and implement improvements. **Holistic patient care:** Integrate counseling, physiotherapy, and economic reintegration programs for fistula patients. Improve patient tracking (e.g. mobile health follow-up reminders) to increase post-repair follow-up and support.

8.7 Conclusion

Obstetric fistula, often termed a "preventable tragedy," encapsulates many of the failures and inequities in maternal health systems. In Malawi, the journey to developing a fistula typically involves a cascade of missed opportunities across the three delays: delayed decision-making due to sociocultural barriers, delayed arrival due to distance and poverty, and delayed care due to systemic weaknesses. Yet this analysis also highlights that each delay offers a corresponding point of intervention. By simultaneously addressing the **social determinants** (empowering women and communities), the **geographic and logistical barriers** (improving access to care), and the **quality of medical services** (strengthening the health system), Malawi can make meaningful strides toward eliminating obstetric fistula. The task is undeniably challenging – requiring coordinated action from the community level up to national policy – but it is achievable. The next and final chapter will distill the key findings of this research and present specific recommendations aligned with these insights, with the aim of informing strategies that can hasten the end of obstetric fistula in Malawi.

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CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 Introduction

Building on the empirical findings presented in Chapter 8, this chapter synthesizes the study's core insights using the Three Delays framework as a lens for systemic appraisal. While the previous chapter focused on presenting results, this chapter aims to critically consolidate those findings, distilling how each delay contributes to both the persistence and mismanagement of obstetric fistula in Malawi. By mapping the interactions between individual decision-making, geographic accessibility, and facility-level readiness, we demonstrate that obstetric fistula is not merely a clinical outcome but a structural failure across multiple tiers of the health system. The following summary table offers a consolidated overview of key challenges and pathways for intervention aligned to Delays 1, 2, and 3.

Table 9 ***:Summary of Key Findings Framed Through the Three Delays Model***

Delay	Core Challenges Identified	Impact on Fistula Prevention	Impact on Fistula Treatment	Strategic Opportunities
Delay 1 Decision to Seek Care	- Stigma and social exclusion - Low awareness of fistula as treatable - High rates of early marriage & adolescent pregnancy - Poverty and lack of decision-making power	- Delayed ANC booking - High rates of home delivery or use of unskilled attendants - Missed opportunity for intrapartum complication prevention	- Median delay of 7.2 years before seeking surgical care - Women suffer in silence and isolation	- Community sensitization campaigns - Empowerment through male involvement & survivor networks - Integration of TBAs in referral pathways under supervision
Delay 2 Reaching Health Facility	- 2 in3 of women live >2 hours from fistula centres - Poor transport infrastructure - Centralized surgical services in Lilongwe	- Failure to reach EmOC in time, leading to obstructed labour	- Travel barriers to fistula repair centres - Post-operative follow-up constrained by distance	- GIS-enabled planning of new repair sites - Transport vouchers & maternity waiting homes - Mobile outreach surgery in hotspot districts
Delay 3 Receiving Adequate Care	- Only 3 active fistula surgeons (all in Lilongwe) - Limited theatre infrastructure in district hospitals - Post-op	- Inadequate EmOC & lack of timely Caesarean delivery for obstructed labour	- 92% anatomical closure success, but <36% follow-up return rate - Psychosocial & contraceptive care poorly integrated	- Expand surgical training & decentralize repair sites - Adopt mHealth for follow-up - Strengthen

	reintegration & follow-up weak			psychosocial & reproductive health integration

Bringing these findings together, the study paints a comprehensive picture of obstetric fistula as an outcome of intersecting delays. A woman's likelihood of suffering fistula – and her chances of accessing a cure – depend on **social factors** (education, stigma, economic status), **spatial factors** (proximity and transport to health facilities), and **health system factors** (availability and quality of EmOC and surgical care). By using the Three Delays framework, we demonstrated that fistula is not merely a clinical injury but a symptom of broader health system failures. Encouragingly, this also means that progress can be achieved on multiple fronts: **empowering women and communities (to address Delay 1), improving physical access (Delay 2), and strengthening health care delivery (Delay 3)**. The key findings summarized above underscore the areas where strategic interventions can both **prevent new fistulas** (e.g. through better obstetric care and earlier health-seeking) and **improve outcomes for women living with fistula** (through more accessible, high-quality repair and follow-up care).

9.2 Contributions to Theory, Policy, and Practice

Contribution to Theory and Knowledge

This thesis makes several contributions to the theoretical understanding of maternal health access and obstetric fistula. First, it **refines the Three Delays model** by applying it specifically to obstetric fistula and demonstrating its usefulness beyond acute maternal mortality outcomes. Our integrated analysis showed how delays at every stage of care interact to produce the tragic outcome of fistula and how they must be addressed in tandem. Notably, by incorporating **geospatial analysis** into a traditionally social and clinical framework, we advanced a more holistic conceptualization of the Three Delays. The study's **multidimensional approach** – combining epidemiological data, spatial mapping, and clinical outcomes – is an innovative contribution in the fistula research field. This approach highlighted, for example, the geographic clustering of fistula cases in relation to health facility distribution, adding a new layer to the theory of access barriers. It suggests that the classic Three Delays model can be **expanded or fine-tuned** for chronic maternal morbidities: we underscore the importance of a potential "fourth delay" – the delay in social reintegration and

ongoing care after treatment, which is particularly relevant for fistula survivors. Additionally, the thesis contributes new epidemiological knowledge on fistula in Malawi, including updated prevalence estimates, risk factor correlations, and outcomes of surgical repair. These findings fill a gap in the literature for Malawi and similar low-income settings where fistula data was previously sparse. Overall, the research design and findings demonstrate how **integrating diverse data sources and methods** can yield richer insights into maternal health challenges, thereby contributing methodological lessons to the field. The use of **GIS technology in maternal health** is itself a contribution to theory and practice – showcasing how spatial inequities critically shape health outcomes and why theories of health service access must account for geography.

Contribution to Policy

The study's findings carry significant implications for health policy in Malawi and in global maternal health strategy. Firstly, our evidence aligns closely with and supports the aims of **Malawi's National Obstetric Fistula Strategy (2023–2030)** and the **National Surgical, Obstetric and Anesthesia Plan (NSOAP)**. The national strategy's goal of **preventing and ending fistula by 2030** is affirmed by our identification of key gaps that must be addressed to meet that target [(1).] For instance, the strategy calls for building capacity to manage fistula cases in *all district hospitals* as part of universal health coverage [(1)]. Our finding that over 80% of repairs occur in one urban center, leaving high-prevalence rural districts underserved, provides the empirical justification for this policy – highlighting the urgent need to **decentralize services and train personnel across the country**. Likewise, Malawi's NSOAP emphasizes strengthening maternal surgical care; our documentation of workforce shortages and long repair backlogs gives NSOAP concrete targets (e.g. increasing the number of trained fistula surgeons and distributing them more evenly) Importantly, this thesis contributes to policy by quantifying inequities and thus helping prioritize resource allocation: health planners can use our GIS maps and analyses to identify **hotspot regions** that require new fistula centers or improved transportation networks.

At the international level, the research speaks to global commitments such as the **Sustainable Development Goals (SDGs)**. Ending obstetric fistula is implicitly linked to achieving SDG 3 (maternal health and well-being) and SDG 5 (gender equality), among others. Our work underscores that without accelerated investments in maternal health, the UN's ambitious target to end fistula by **2030 will remain unattainable** [2.] It provides evidence that can be used by

policymakers and advocates to lobby for more funding and action – for example, showing that only a fraction of women receives timely fistula treatment and that many are left behind in the current system. The persistence of fistula, as our study reiterates, is essentially a **human rights failure**, reflecting marginalized women's lack of access to basic care[3]. By framing fistula as both a health and human rights issue, the thesis supports policy arguments for equity-focused interventions (such as removing user fees for maternal services, expanding insurance coverage, and enforcing laws against child marriage which is an upstream cause of teenage pregnancies and fistula [3]. In summary, this research provides policymakers in Malawi and similar contexts with **evidence-based insights** to guide strategy: it identifies where and why current strategies are falling short and suggests how policies like the national fistula strategy and NSOAP can be operationalized more effectively. Our findings have already been communicated to stakeholders during the study, contributing to ongoing policy dialogues. Thus, the thesis serves as a bridge between research and policy, ensuring that the data generated can inform planning and help align national efforts with global goals (e.g. the Campaign to End Fistula and SDG targets)[3].

Contribution to Practice

Practically, the study offers valuable lessons and tools for improving maternal health service delivery in Malawi. One of the key contributions is the identification of **critical gaps in the health system** – for example, the shortage of skilled providers and uneven distribution of services – and translating these into actionable solutions. The evidence supports practical interventions such as **decentralizing fistula repair services** (e.g. establishing additional fistula repair centers in the Northern and Southern regions) and **task-shifting** (training more mid-level health providers in fistula case identification and post-operative care. These recommendations, grounded in our data, are aimed at making care more accessible to women in need. The study also contributes to practice by emphasizing the importance of **community engagement and patient follow-up**. Recognizing that only 36% of women returned for follow-up after surgery points to the need for better patient tracking and support systems – for instance, involving community health workers to follow up with repaired patients in their villages. By highlighting that many women lived with fistula for years due to stigma and lack of awareness, our work underscores the role of community education and **fistula awareness campaigns** as a routine part of maternal healthcare outreach. In practice, this could mean integrating fistula screening questions into postpartum care visits or antenatal care counseling

so that women know when and how to seek help if they experience incontinence after childbirth.

Another practical contribution is the use of **geospatial mapping as a decision-support tool**. Health managers and district officers can utilize the maps of travel times and fistula prevalence generated by this study to plan outreach clinics, mobile surgical camps, or ambulance routing more effectively. This GIS approach to analyzing service coverage can be applied to other aspects of maternal health as well, making our methodology broadly useful for health service delivery planning. Furthermore, the thesis brings to light the **success factors for fistula repair outcomes**, which can inform clinical practice – for example, identifying that timely presentation and nutrition status affect surgical success could lead practitioners to incorporate nutritional support and earlier referrals into patient management. The combined analysis of **clinical and health system data** in this work is a practical demonstration of how a health system can be evaluated holistically; this approach can be replicated by practitioners and hospital administrators to continuously assess and improve readiness for obstetric emergencies. In essence, the study's contributions to practice lie in its evidence-driven recommendations (detailed below) and in providing a model for how to integrate data to guide improvements. By **linking research to action**, the thesis helps ensure that maternal health services in Malawi (and similar low-resource settings) can be strengthened in ways that are directly responsive to the identified needs and gaps. The next section translates these contributions into concrete recommendations for key stakeholders.

9.3 Recommendations for Malawi and Similar LMIC Contexts

Drawing on the findings above, this concluding section presents a set of **concrete, evidence-based recommendations** targeted at various stakeholders – including the Ministry of Health (MOH) in Malawi, district health management teams, development partners, and community leaders. These recommendations are organized into five key areas: **community-level interventions, health system strengthening, service decentralization, quality of care improvements, and post-repair reintegration**. Together, they form a comprehensive strategy to prevent obstetric fistula and improve care for affected women, in alignment with Malawi's national goals and global best practices.

1. Community-Level Interventions: Prevention and Early Care-Seeking

Empower Communities through Education and Engagement: Launch widespread **fistula awareness and maternal health education campaigns** in communities, particularly in high-prevalence rural districts. Such campaigns (via radio, community theatre, women's groups, and schools) should teach that obstructed labour is dangerous, and fistula is preventable and treatable. Increasing knowledge will help erode the stigma that currently keeps women hidden and delays care. Community and religious leaders should be enlisted as champions to communicate that fistula is a medical injury – not a curse – and to encourage families to support women in seeking prompt maternity care and fistula treatment.

Address Sociocultural Barriers and Gender Inequities: Work with local leaders to **discourage child marriage and teenage pregnancy**, and promote girls' education, as these are known risk factors for obstetric fistula[3]. Strengthening the enforcement of laws against early marriage and supporting girls to remain in school will, over time, reduce early childbearing by adolescents whose bodies are not ready for safe childbirth. Likewise, empower women economically (through village savings loans, vocational training, etc.) so that they have more decision-making power and resources to seek health care. Efforts to **promote gender equality and women's status** not only contribute to broader development goals, but also specifically help prevent fistula by delaying first pregnancy and ensuring women can access care without needing permission or funds from a male partner [5].

Community Emergency Transport, Birth Preparedness, and TBA Integration Addressing the second delay requires practical, community-driven solutions that bridge the gap between households and health facilities. Local maternal emergency transport schemes—such as bicycle ambulances, stretcher teams, or community-managed fuel funds—can provide rapid transfer for women in labour. Maternity waiting homes near district hospitals offer an effective option for women in late pregnancy who live far from care, reducing distance-related delays. Community leaders, Health Surveillance Assistants (HSAs), and repositioned Traditional Birth Attendants (TBAs) should collaborate to identify high-risk pregnancies, promote antenatal and postnatal attendance, support advance planning for facility delivery, and accompany women to skilled care. By combining transport readiness, birth preparedness, and culturally accepted TBA engagement, these initiatives directly address geographic, financial, and sociocultural barriers—ensuring timely access to emergency obstetric care and reducing the incidence of obstructed labour and fistula.

Leverage Fistula Survivors as Advocates: Engage treated fistula survivors in community education roles – for instance, as **"Fistula Ambassadors"** who conduct outreach to villages to find hidden cases and advise pregnant women. Evidence from other settings shows that women who have overcome fistula can effectively reduce stigma by sharing their stories, and that serving as advocates also benefits their own recovery [4]. The MOH and partners should support training and modest compensation for these survivor advocates. Their presence in the community puts a human face on fistula, helping to **normalize conversations** about maternal injuries and encouraging other women to seek care early. It also facilitates identification of women still suffering in silence, creating a bridge from the community to health facilities.

2. Health System Strengthening: Workforce and Infrastructure

Expand and Equitably Distribute the Health Workforce: A top priority is to **increase the number of skilled personnel** available to provide both emergency obstetric care and fistula repair services. The Ministry of Health, with support from academic institutions and development partners, should fast-track training for more obstetricians, gynaecologists, and nurses in comprehensive emergency obstetric care (CEmOC). Invest in a **fistula surgery training program** – Malawi could partner with initiatives like the FIGO Fistula Surgery Training Initiative to train more surgeons [3]. Given the current shortage (only3 active fistula surgeons based at Bwaila), the goal should be to train a cohort of doctors (and interested clinical officers) in fistula repair and to retain them in the public health system. **Task-shifting** strategies are recommended: for example, empowering specialist midwives or clinical officers with additional skills to perform simpler fistula repairs or to manage postoperative care can extend the reach of available experts. Crucially, incentives (such as hardship allowances, career development opportunities, and recognition) should be provided to encourage skilled providers to serve in **rural and underserved areas**. The MOH should strive for an equitable distribution of surgeons, anesthetists, and midwives so that every region has sufficient staffing to handle obstetric emergencies and routine fistula cases.

Upgrade Infrastructure and Supplies for Maternal Health: Health facilities, especially at the district level, must be equipped to deliver quality obstetric care. This entails ensuring that **every district hospital has a functioning operating theatre, adequate medical supplies, and blood transfusion capacity** to perform emergency Caesarean sections 24/7. Many fistulas can be prevented if obstructed labour is relieved by a timely C-section. Therefore, the government and partners should audit and invest in closing the gaps in EmOC signal functions

across the country (e.g. ensuring availability of anesthesia, sterilization equipment, etc.). Additionally, for fistula management, hospitals need specialized instruments and continuous supplies (foley catheters for early management, fistula repair sets, proper lighting, etc.). Strengthening infrastructure also means improving **basic amenities** – maternity wards need water and sanitation (to prevent infections) and sufficient beds, while fistula wards should have the facilities to allow women to stay post-repair until fully healed. Development partners can assist by funding the refurbishment of key hospitals and by providing equipment. In line with the **NSOAP**, a costed plan should be developed to incrementally build surgical capacity at peripheral hospitals over the next 5–10 years. This plan should also integrate with the National Fistula Strategy's aim of making fistula services available "at all district hospitals" effectively bringing care closer to where women live.

Improve Health Financing and Remove User Barriers: Financial constraints are a recurring theme affecting all three delays. While Malawi has a policy of free maternity services, in practice women incur costs for transport, supplies, or opportunity costs of time. It is recommended to strengthen financial protection mechanisms: for example, establish a transport voucher system or community loan funds for obstetric emergencies so that no woman is unable to reach a facility due to cost. The MOH and district governments should also ensure that fistula repair surgeries remain free of charge and consider providing a stipend or support package for women coming for treatment (to cover their travel and food). Development partners could earmark funds for an "Obstetric Fistula Care Fund" that supports these patient expenses and community transport initiatives. By mitigating financial barriers, these steps encourage early care-seeking (Delay 1) and help women adhere to referrals and follow-ups (Delays 2 and 3). Moreover, incorporating fistula indicators into national health insurance or results-based financing schemes could incentivize facilities to actively find and treat cases.

3. Service Decentralization: Bringing Fistula Care Closer

Establish Regional Fistula Treatment Centers: A major recommendation from this study is to **decentralize fistula repair services** out of the single central hub. The Ministry of Health should designate and develop at least **3–4 regional fistula centers** – for instance, one in the Northern Region and additional centers in the South (in or near high-prevalence districts like Mangochi or the Lower Shire area). This can be achieved by upgrading surgical capacity at selected district or regional hospitals and posting trained fistula surgeons there. Our findings showed that current services are highly centralized, with most women needing to travel to

Lilongwe for care. Decentralizing will reduce travel times and costs for patients (tackling Delay 2) and likely increase the uptake of surgery among those suffering in remote areas. It will also help **clear the backlog** of untreated fistulas by expanding overall national capacity. In implementing this, the MOH can adopt a phased approach: start by conducting **periodic outreach repair camps** in underserved regions (bringing surgeons from Lilongwe or abroad to operate on batches of patients), then gradually build permanent local teams. Development partners (e.g. UNFPA, Fistula Foundation) have significant experience with outreach models and can provide support in logistics and funding.

Strengthen Referral Networks and Transportation: Decentralization is not only about physical infrastructure but also about functional referral linkages. The MOH and district health management teams should strengthen the **referral system**s that when women with fistula are identified at health centers or district hospitals, they can be quickly referred to the nearest fistula treatment site. This may involve setting up a **nationwide fistula hotline or ambulance referral system**, where cases can be referred and transported without delay. Better coordination and communication (e.g. using mobile phones for referral calls, dedicated ambulance days for obstetric cases) will ensure that once a woman decides to seek care, she can reach the appropriate facility (minimizing Delay 2). It is also recommended to integrate fistula services into the broader maternal health services network – for instance, training midwives to screen for fistula during postnatal checks and refer women early. By decentralizing services and enhancing referral pathways, Malawi's health system can move towards the National Strategy's vision of **managing fistula "in all district hospitals" and achieving more equitable access as part of universal health coverage**[1].

Leverage Mobile and Outreach Services: In addition to fixed facilities, consider adopting **mobile outreach clinics** for fistula and maternal health. These are teams that periodically visit remote areas to provide services such as continence care, screening for fistula, or even minor surgical repairs. Our spatial analysis identified specific pockets of high need; targeted outreach to these communities can be a stop-gap measure while permanent services are being established. This approach has been used in other countries to great effect, finding women who could not travel and providing them care closer to home. Outreach can also serve as a form of advocacy – the presence of a "fistula camp" in a district raises awareness about the condition and can spur more women to come forward for treatment. Development partners

can play a role by sponsoring such outreach efforts, and by bringing in external expert surgeons to work alongside Malawian teams in decentralizing care.

4. Quality of Care Improvements: Ensuring Effective Maternal Health Services

Improve Quality of Obstetric Care (Fistula Prevention): Since obstetric fistula is almost entirely preventable with good-quality intrapartum care, a key recommendation is to **bolster the quality of maternal health services across the board**. The Ministry of Health should reinforce adherence to proven interventions like **monitoring every labour with a partograph, timely decision-making for Caesarean section, and using vacuum / forceps when indicated** [3]. Regular in-service training and mentorship for maternity staff is needed, focusing on emergency obstetric and newborn care competencies. We suggest implementing a **"zero tolerance for obstructed labour" policy**, meaning any labour that deviates from normal progress triggers an immediate response (call for a higher-level clinician or transfer). This requires empowering nurses and midwives at primary facilities to recognize danger signs and act decisively. Another aspect of quality is ensuring **skilled birth attendance for all deliveries** – the MOH must continue to increase the percentage of births attended by trained professionals (currently around 90% nationally, but lower in some pockets). Community-level interventions recommended (like maternity waiting homes and transport) will support this by getting women to facilities; once there, quality must be assured. By preventing obstructed labours through quality care, new fistula cases will drop – directly contributing to the national goal of zero fistulas.

Standardize and Enhance Fistula Treatment Quality: On the treatment side, maintaining high quality of surgical and postoperative care is crucial for successful outcomes. The MOH should adopt standard **clinical protocols for fistula management**, aligned with international guidelines (such as the new **WHO/UNFPA obstetric fistula surgical handbook**). All fistula surgeons and teams in Malawi need opportunities for continuous professional development – attending surgical workshops, engaging in peer learning, and periodically having external experts for coaching to refine techniques. Ensuring quality also means having the necessary supplies (antibiotics, anaesthetics, sutures of the right type for delicate fistula tissue, etc.) consistently available. Infection prevention practices must be stringently followed to avoid post-operative complications. We also recommend improving the **pre-operative preparation and post-operative nursing care** for fistula patients: for example, providing physiotherapy (to strengthen pelvic muscles), nutritional support if women are malnourished, and careful

wound care and catheter management after surgery. High-quality care will improve closure rates and continence outcomes, which in turn encourages more women to seek treatment (because they hear of success stories). The thesis findings about some women experiencing residual incontinence or not returning for follow-up highlight areas to improve – e.g., maybe the need for second surgeries in some cases, or better counseling on pelvic floor exercises. A **quality improvement collaborative** could be established among the fistula treatment sites, where teams regularly review outcomes, share challenges, and solve problems together. Development partners can support with technical expertise for such collaborative quality improvement efforts. Ultimately, making every repaired woman a "success story" by providing top-notch care will boost community trust and demand for services, feeding back into earlier care-seeking (addressing Delay 1 indirectly).

Integrate Fistula Services into Routine Healthcare: Quality improvement also involves integration. Fistula care should not exist in isolation but be embedded into **routine maternal and reproductive health services**. For example, training family planning providers to counsel fistula patients on contraceptive options (to delay any future pregnancies until fully healed, or indefinitely if advised) is a quality aspect that links services. Another example is integrating mental health support given the psychological trauma associated with fistula, having counsellors or social workers as part of the fistula care team will improve the overall quality of care and patient satisfaction. The Ministry should ensure that fistula prevention and management are included in all relevant guidelines, from **reproductive health policies to training curricula for health workers** [3]. By mainstreaming fistula into the healthcare system, quality is more likely to be sustained and monitored, rather than being an "NGO-led" vertical program. Routine health management information systems (HMIS) should also capture fistula cases and repairs as quality indicators, prompting facilities to pay attention to these outcomes. In summary, a culture of **quality improvement in maternal health** – through training, protocols, supplies, and integration – is essential to both **prevent fistulas and ensure that those that do occur are managed effectively and compassionately**.

5. Post-Repair Reintegration: Restoring Dignity and Supporting Survivors

Holistic Rehabilitation Services: Repairing the physical injury is only the first step in restoring a woman's life after fistula. We recommend developing **comprehensive reintegration programs** for fistula survivors as a standard component of fistula care. The Malawian Ministry of Health, in partnership with social services and NGOs, should establish

a package of post-repair support that may include counseling, health education, skills training, and economic empowerment. For instance, after surgery (especially for women who must stay at the center for 2+ weeks of healing), provide **psychosocial counseling** to address trauma and rebuild self-esteem. Group therapy or peer support sessions among fistula patients can help them share experiences and coping strategies. UNFPA emphasizes that a **holistic approach addressing psychosocial and socioeconomic needs** is vital for full recovery[3]. In practice, this could mean creating **rehabilitation centers or halfway homes** where women can stay for a period after surgery to receive counseling, adult literacy lessons, or learn a trade (such as sewing, baking, etc.). Equipping women with skills and small grants or tools to start an income-generating activity helps ensure they are not returning home empty-handed or to the same extreme poverty that contributed to their condition[3]. Such support also tackles stigma by giving women a means to reassert their role in the community beyond their identity as a fistula patient.

Community Reacceptance and Family Support: Reintegration is a social process. Community leaders and family members should be sensitized to **welcome repaired women back without discrimination**. We recommend that community outreach around fistula include messaging that "**fistula is curable, and the woman is whole again**." Traditional leaders can even organize **ceremonies or public statements** to mark a woman's return, which can symbolically cleanse any stigma. The Ministry, along with civil society groups, can facilitate **home visits** by community health workers to families of fistula survivors, educating them on the woman's needs and encouraging spouses to be supportive (e.g., resuming marital relations only when safe, accompanying her to follow-up visits, etc.). In cases where a woman was abandoned by a husband due to fistula, authorities and NGOs could assist in legal and social support – for example, ensuring she has shelter and means of living. Given that many women with fistula suffer isolation, creating **fistula survivor networks** (support groups at the community or district level) can be extremely beneficial. These networks allow women to continue sharing experiences, and perhaps even engage in joint economic activities. There is evidence that women who become advocates or peer supporters experience improved mental health and social reintegration themselves[4]. Therefore, supporting survivor-led groups kills two birds with one stone: it aids the women involved and spreads awareness to prevent future cases.

Follow-up Care and Maternal Health Integration: Post-repair follow-up is critical medically and for reintegration. We found that only a third of women returned for their check-up, which means complications could go unmanaged and some women might develop recurrent

fistula in subsequent births. To improve this, the health system should **proactively track and follow up with repaired patients**. For example, each treated woman's contact details can be given to a nearby community nurse or HSA, who then visits her at home at regular intervals (6 weeks, 6 months, 1-year post-op) to check on her continence status and wellbeing. Where possible, integrate these follow-ups with routine services – when a fistula survivor becomes pregnant again, flag her as high-risk so that she receives tailored antenatal care and a planned C-section to protect her from re-injury[3]. The MOH could develop a simple **database or registry of fistula patients** for tracking outcomes and reminding women of follow-up appointments via SMS or community worker. Development partners could assist by funding transportation for follow-up visits or decentralizing follow-up to local clinics (e.g., allowing a woman to get her catheter removed at the district hospital closer to home by a trained nurse, rather than traveling back to the fistula center). Ensuring robust follow-up not only safeguards the woman's physical health but also signals to communities that the health system cares for these women long-term. This helps shift the narrative from one of "one-off charity surgery" to a message that fistula survivors are still valued patients whose health needs continue to be important.

In sum, these recommendations call for **multi-sectoral action**: the Ministry of Health providing leadership and resources; district health managers implementing improvements on the ground; development partners supplying technical and financial support; and community leaders driving cultural change. By addressing the **root causes (Delays 1 and 2)** of obstetric fistula and improving the **readiness of health services (Delay 3)**, while also **healing the wounds beyond the physical** through reintegration efforts, Malawi can make significant strides toward eliminating obstetric fistula as a public health problem. Not only do these actions align with Malawi's National Fistula Strategy and commitments to the SDGs, but they also resonate with approaches needed in similar low- and middle-income countries where fistula persists. The roadmap to end fistula requires **community empowerment, health system strengthening, and human rights-based care**, all of which are reflected in the above recommendation[3,5].

9.4 Future Research Directions

While this study has advanced understanding of obstetric fistula in Malawi, it also uncovers **knowledge gaps and new questions** that warrant further research. The following are

key areas for future inquiry, along with suggested approaches that could deepen insights and inform ongoing efforts:

- **Longitudinal Outcomes and Survivors' Wellbeing:** One gap is understanding the long-term outcomes for women after fistula repair – medically, socially, and economically. Future research should employ **longitudinal designs** following repaired patients over years to assess continence status, fertility and childbirth outcomes, mental health, social integration, and economic stability. Such studies could identify predictors of successful reintegration and areas where additional support is needed (for example, how many women remain childless due to fear of recurrence, or the divorce rate post-repair). Qualitative components (through in-depth interviews) would enrich these studies by capturing women's personal journeys of recovery. In Malawi, a follow-up study of the women in this thesis' cohort, or a new cohort, could be invaluable to evaluate the effectiveness of any new reintegration programs and to ensure that "cured" women are truly thriving in the long run.
- **Intervention Research for Prevention:** There is a need for rigorous research on interventions aimed at preventing obstetric fistula. For instance, future studies could pilot community-based programs – such as a targeted maternal education intervention or a transport voucher scheme in a rural district – and evaluate their impact on delays in care-seeking and incidence of obstructed labour and fistula. A **cluster-randomized trial** or quasi-experimental design (comparing communities with and without the intervention) could provide high-quality evidence on what works to reduce the first and second delays. Additionally, operations research on maternity waiting homes (are they being used by the right women? do they reduce obstructed labour rates in that area?) would be useful to optimize these facilities. This kind of implementation science will help translate our findings into effective practice, and results from Malawi could inform other countries implementing similar community interventions.
- **Health Systems and Policy Research:** Building on our health system analysis, further research should examine the process and impact of scaling up fistula services. For example, as Malawi implements decentralization of fistula care, researchers should study the outcomes: Does bringing services closer significantly shorten the average duration women live with fistula? What are the cost-effectiveness and quality implications of decentralized versus central repair services? Such research might involve a **mixed-methods evaluation** of a pilot decentralization initiative, combining

quantitative metrics (number of repairs done, reduction in backlog, patient travel distances) with qualitative feedback from patients and providers at new fistula centers. Another policy-related gap is how to effectively integrate fistula care into the broader maternal health system – research could explore models of care integration (for instance, training general surgeons at district hospitals to repair fistulas vs. deploying specialized teams periodically). Comparative case studies of districts (or neighbouring countries) that have different models could yield insights into best practices for institutionalizing fistula services.

- **Geospatial and Epidemiological Modeling:** Our study leveraged GIS and national survey data to describe fistula patterns; future research can expand this by developing **predictive models** to identify communities at highest risk of obstetric fistula. Incorporating additional spatial data – such as road network improvements, distribution of EmOC facilities, or even mobile phone connectivity (as a proxy for ease of calling ambulances) – into predictive models could help forecast where fistula incidence might rise or decline. Researchers could also use spatial statistical techniques to evaluate, over time, whether interventions (e.g., a new hospital or road) correlate with reduced fistula prevalence in that area. Another epidemiological research direction is to refine estimates of fistula incidence and prevalence. Current figures rely on self-reported survey data; a more robust approach could be establishing a **national fistula registry** or surveillance system integrated with maternal death audits. Piloting such a system in a few hospitals could assess feasibility and accuracy, potentially providing a model to continuously measure progress toward eradication by 2030.
- **Innovations in Care and Technology:** To advance the field, researchers should also explore innovative technologies or approaches for fistula prevention and treatment. For example, could **telemedicine** enable rural health workers to consult specialists about managing obstructed labour or obstetric fistula post-op care? Could simple diagnostic tools be developed for early identification of obstructed labour (to intervene faster) or small fistula detection in the community? Additionally, biomedical research into improving surgical techniques or postoperative recovery (perhaps new biomaterials for tissue repair, or better management of scar tissues) could improve success rates. Engaging in multi-disciplinary research – combining medical, engineering, and social science – may produce novel solutions that we have not yet considered. Given the push to end fistula globally, there may be opportunities for Malawi to participate in **multi-country research initiatives** or trials of new interventions (such as testing a

community education package across several countries to see its effect on fistula knowledge and stigma).

- **Social and Economic Research on Survivors:** Beyond health outcomes, there are social science questions about how to best support women who have endured fistula. Future qualitative studies in Malawi could focus on topics like marital dynamics post-repair, community attitudes over time (is stigma lessening with more awareness?), and the economic rehabilitation of survivors. One specific angle is exploring the role of men and family in both the occurrence and recovery from fistula – research could investigate how male partner support (or lack thereof) influences women's care-seeking and reintegration. Another area is evaluating psychosocial interventions: for example, do support groups or "fistula mentor" programs measurably improve women's mental health and confidence? With mental health being an often-overlooked aspect, researching culturally appropriate counseling or group therapy models for fistula patients could guide integration of mental health services in fistula care (an area currently lacking evidence). In summary, a deeper understanding of the **lived experiences of fistula survivors** will help tailor programs to what women need to reclaim their lives.

In pursuing these future research directions, it will be important to use **methodological innovations** and robust study designs to strengthen the quality of evidence. Wherever possible, longitudinal tracking, use of control groups, and triangulation of quantitative and qualitative data will enhance the validity of findings. Additionally, participatory approaches that involve communities and fistula survivors in designing research questions can ensure that studies address relevant issues and ethical considerations (given the vulnerable status of this population). Finally, south-south collaboration – sharing experiences and data with researchers in other low-income countries facing fistula – can accelerate learning and avoid duplication of effort. The knowledge gaps identified are not unique to Malawi; by addressing them, the research community will be contributing to a global learning agenda on obstetric fistula.

9.5 Conclusion

In closing, this thesis has examined obstetric fistula in Malawi from multiple perspectives – clinical, spatial, and socio-cultural – to understand the challenges and opportunities in both preventing this condition and caring for those affected. The **key message** is that obstetric fistula, as a maternal health tragedy, encapsulates the failings of a health system to provide

timely, equitable, and quality care. Yet, the findings also spotlight clear avenues for change. By tackling the issues in each of the Three Delays, "Malawi can make measurable progress towards the **elimination of fistula**, a goal set for 2030 in line with international commitments"[1,3]. The recommended actions – from empowering communities and improving transport, to expanding the health workforce, decentralizing services, and ensuring holistic rehabilitation – form an integrated response that addresses both **the upstream causes and downstream consequences** of fistula.

The study's contributions to theory, policy, and practice reinforce each other: a refined understanding of delays and access informs better policies, and those policies must translate into practice that directly benefits women and girls. Importantly, while grounded in the Malawian context, these insights have relevance for other low-resource settings. Countries across sub-Saharan Africa and Asia that struggle with maternal health inequities and fistula burdens can draw lessons from this work – whether it be the use of GIS mapping to guide interventions or the emphasis on rights-based, patient-Centered care. The principle of "**leaving no one behind**," which underpins the SDGs, is exemplified in the fight against fistula [2]. Women with obstetric fistula are among the most marginalized, often young, poor, and voiceless. Intervening on their behalf not only restores their dignity and health, but also strengthens the overall healthcare system to serve all mothers better.

Finally, this thesis ends with a reflection that eliminating obstetric fistula will require sustained commitment, innovation, and compassion. The road ahead will involve scaling up what works, honestly confronting what does not, and continually engaging communities in the solution. The findings and recommendations herein serve as a **bridge between evidence and action**, offering a roadmap for stakeholders in Malawi – from the Ministry of Health down to village leaders – to coordinate efforts in preventing and managing fistula. If the momentum from research and advocacy is maintained, Malawi can become a success story in fistula eradication, contributing to the global campaign to end this preventable condition. In doing so, it will affirm the fundamental truth that **no woman should suffer incontinence and indignity from childbirth** in the 21st century. The journey to that reality is challenging but achievable, and it has been the aim of this research to bring that goal closer within reach through data-driven insight and actionable guidance. The task now lies with all of us – researchers, policymakers, health workers, and communities – to turn these insights into real improvements that ensure **safe motherhood and restored hope** for every woman, in Malawi and beyond.

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Epilogue: Reflection on My PhD Journey

My PhD journey has been far more than an academic pursuit – it has been a deeply personal and transformative chapter of my life. A significant part of that journey was shaped by my three years serving with the Likoma District Health Office. Likoma Island, though not the epicentre of Malawi's fistula burden, offered a profound window into the realities of hard-to-reach health systems. As the district's clinician, I worked across outreach, antenatal services, emergency obstetric care, and community referral pathways. It was a landscape where health service delivery was defined not only by clinical decision-making but equally by geography, lake transport schedules, weather patterns, and resource limitations.

Likoma taught me the fragility of referral chains in isolated settings. During one emergency outreach evacuation, our small boat began taking in water mid-crossing — a moment that revealed the stark contrast between clinical urgency and physical accessibility. If reaching the mainland could be so precarious for trained health workers, the journey for a woman in obstructed labour was infinitely more perilous. These experiences did not merely inform my interest in maternal health; they shaped the core questions of this thesis and my conviction that obstetric fistula is as much a systems failure as it is a clinical injury.

Across Malawi, larger districts such as Mangochi represent the true scale of the burden — vast populations, long distances, poor terrain, and delayed access to emergency obstetric care. My work across both isolated islands and high-volume districts illuminated the spectrum of barriers that women face. Together, these environments taught me that a woman's risk is shaped by far more than the physiology of labour; it is shaped by the terrain she must navigate, the transport she must secure, and the timeliness of the care she can reach.

Within this complex health landscape, the Bwaila Fistula Care Centre has served as a national anchor — a place where world-class fistula repair is delivered through the dedication of teams who have transformed maternal morbidity outcomes in Malawi. Under the leadership of Prof Jeff Wilkinson, Dr Ennet Chipungu, and an extraordinary multidisciplinary team, Bwaila has become a national barometer for repair outcomes, follow-up care, and reintegration support. Their work directly informed the decade-long audit forming one of the pillars of this thesis. As Malawi advances its 2023–2030 National Obstetric Fistula Strategy in partnership with the Ministry of Health, UNFPA, and the Freedom from Fistula Foundation, there is renewed hope that women in remote, lakeshore, and high-burden districts alike will access timely, dignified fistula care.

I have been fortunate to walk this journey with exceptional mentors whose influence has shaped both my scientific lens and my professional identity. Prof Salome Maswime has been a steadfast guide, instilling in me the principles of global surgery, maternal health equity, and the systems approach that underpins this thesis. Prof Amos Adelowo of Massachusetts, whose mentorship spanned years before we finally met at the IUGA Annual Meeting in The Hague, enriched this work with clinical depth and global perspective. Their mentorship has shaped not only the research but the surgeon-scientist I am becoming.

This PhD has opened doors to a wider network of global surgery leaders, pelvic floor experts, and fistula surgeons whose work continues to inspire me. Sharing the stories of the women I served in Malawi, Namibia, and South Africa has created collaborations rooted in shared purpose — reinforcing my belief that advancing maternal health is both a scientific responsibility and a moral calling.

As I close this chapter, I recognise that this thesis is not simply a collection of analyses; it is a bridge. A bridge between women whose resilience shaped my calling, mentors who shaped my thinking, and a global community shaping my future work. Above all, this thesis rests on a single belief: **where a woman lives should never determine her survival, her safety, or her dignity**.

With gratitude, strengthened insight, and renewed purpose, I step forward committed to the work ahead — building systems, mentoring future clinicians, and advancing innovations that honour the resilience, courage, and dignity of the women who inspired this journey. This is not the end of the story but the beginning of a new chapter — one I hope will illuminate, restore, and transform many lives yet to come.

Candidate Achievements

1. Academic and Research Contributions

I have contributed significantly to international scientific discourse through multiple high-impact presentations across leading global platforms. In October 2025, I presented findings from this doctoral research at the **FIGO World Congress in Cape Town**, one of the most influential global convenings in obstetrics and gynaecology. The accepted poster showcased geospatial modelling of emergency obstetric and fistula care access in Malawi and generated meaningful engagement with policymakers, WHO representatives, and global maternal health leaders.

Earlier in June 2025, I delivered an oral presentation at the **International Urogynaecological Association (IUGA) Annual Meeting** in Spain. Drawing on a clinical dataset of over 2,400 fistula repairs, my presentation provided rare African surgical insights that informed broader discussions on pelvic floor reconstruction and international guideline development.

Previously, in May 2025, I presented at the **International Conference on Innovations in Global Surgery (ICIGS)** in Malawi, where my travel-time modelling work contributed to continental dialogue on strengthening surgical systems in low-resource settings.

Three peer-reviewed publications emerged from this PhD, including:
• a spatial epidemiology analysis,
• a clinical outcomes study that received a **Best Research Paper Award**, and
• a systems-preparedness framework integrating national surveys, surgical readiness assessments, and geospatial intelligence.

Together, these outputs demonstrate strong methodological rigour, clinical depth, and a sustained commitment to advancing evidence-driven maternal health and global surgical research.

I have also translated these research insights into clinical innovation, spearheading the integration of minimally invasive and robotic-assisted pelvic reconstruction within Southern Africa. This aligns with global trends in digital and minimally invasive surgery and positions me as an early contributor to advancing high-quality pelvic care in resource-constrained environments.

2. Leadership and Professional Development

My leadership capacity has grown substantially across clinical, academic, and international domains. Completion of the **Certified Executive Leadership in Global Surgery Programme** at the University of Cape Town Graduate School of Business equipped me with advanced skills for policy engagement, programme leadership, and health-systems strengthening.

As a **National Robotic Surgery Proctor**, I train surgeons across South Africa in robotic hysterectomy, sacrocolpopexy, and complex pelvic floor procedures — supporting national workforce expansion in minimally invasive surgery.

My global standing in surgical innovation is reinforced by my role as **Moderator of the Robotics Session** at the **AAGL Global Congress** (Vancouver, November 2025), one of the world's most prestigious surgical gatherings. This appointment reflects international recognition of my expertise in robotics and surgical innovation.

Within Stellenbosch University, I serve as **Head of Urogynaecology**, shaping clinical services, directing surgical training, and leading research development. I founded and currently direct the **first-ever Fellowship in Urogynaecology and Pelvic Floor Surgery** at the university — a comprehensive programme integrating advanced laparoscopy, robotics, vaginal surgery, and academic mentorship. This fellowship builds national and regional capacity while positioning Stellenbosch as a leading hub for pelvic floor subspecialisation in Africa.

3. Strength of Dual Academic Lineage: UCT → Stellenbosch University

A defining strength of my academic and professional identity is the synergy between my training at the **University of Cape Town** — Africa's top university for clinical medicine and global surgery — and my academic leadership at **Stellenbosch University**, one of the continent's leading centres for research and surgical innovation.

This dual lineage provides a rare combination of global surgery grounding (UCT) and innovation-driven surgical practice (Stellenbosch). It affords cross-institutional networks, access to Africa's top three academic ecosystems, and the ability to translate research evidence into impactful systems-level change. Together, these environments have expanded my capacity for high-impact collaboration and strengthened my role in advancing women's health across the continent.

4. Personal Milestones

Alongside academic and clinical achievements, I reached deeply meaningful personal milestones during this PhD journey. I welcomed two daughters, further grounding my commitment to maternal health and strengthening the emotional purpose behind this work. Completing the **Sanlam Cape Town Marathon (2024)** and the **Two Oceans Ultra Marathon (2025)** reflects the resilience and discipline that have sustained me through the demands of academic and surgical life.

5. Overall Impact

This PhD has shaped me into a surgeon-scientist, educator, and global surgery leader. It reflects a deliberate integration of rigorous research, clinical innovation, academic leadership, and systems-level advocacy. My work contributes to reshaping maternal health and pelvic surgery policy, strengthening training pipelines, and driving surgical innovation anchored in equity. The synthesis of clinical practice and research positions me as a key voice in the next phase of African-led advancement in women's health.

6. ARISE – A Vision for New Beginnings

Building on this foundation, I am pioneering **ARISE (Africa's Robotics, Innovation, Surgery & Equity Initiative)** — a continental platform designed to merge robotics, AI-enabled diagnostics, geospatial intelligence, and immersive VR/AR surgical training with systems-oriented health reforms. ARISE represents a strategic evolution from research to scalable

implementation, aiming to transform surgical care for women and strengthen equitable health systems across Africa. It embodies my commitment to leveraging technology, collaboration, and data-driven strategy to drive sustainable, continent-wide impact.

7. Continental Scientific Leadership – SAUGA 2026

This leadership trajectory culminates in my role as **Scientific Chair of the SAUGA 2026 Congress**, themed **"Innovation for Impact in Women's Health."** Scheduled for February 2026, the congress will bring together global leaders in pelvic surgery, robotics, physiotherapy, obstetrics, biomedical innovation, and health-systems strengthening. As curator of the scientific programme, I oversee academic integrity, thematic design, speaker engagement, and international collaborations — cementing my role as a continental convenor and architect of the next era of women's health and surgical innovation.

APPENDIX

Appendix 1: HREC Approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room 45 E-52-E-Floor- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-submissions@uct.ac.za
Website: www.health.uct.ac.za/home/human-research-ethics

05 December 2022

HREC REF: 744/2022

Prof S Maswime
Department of Surgery
J-Floor OMB
Email: Salome.maswime@uct.ac.za
Student: ktedjere@yahoo.com

Dear Prof Maswime

PROJECT TITLE: OBSTETRIC FISTULA IN MALAWI: PREPAREDNESS FOR THE MANAGEMENT OF OBSTETRIC FISTULA IN MALAWI (A REVIEW OF TRENDS BETWEEN 2013-2023) (PHD CANDIDATE-Dr Khumbo Jere)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 December 2023.

Please submit a progress form, using the standardised Annual Report Form (FHS016) if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Dr Khumbo Jere will also be involved in this study.

Please quote the HREC REF 744/2022 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE

Federal Wide Assurance Number: FWA00001637. Institutional Review Board (IRB) number: IRB00001938 NHREC-registration number: REC-210208-007

HREC/ref 744.2022

Appendix 2: Research Ethics Approval Malawi

Ref. No.:
Telephone No.: 265 726 466/464
Telefax No.: 265 727817
Telex No.:
E-Mail. lilongwedho@malawi.net

COMMUNICATIONS TO BE ADDRESSED TO:

In reply please quote NO DZH/MALAWI,
Lilongwe District Health Office
P.O. Box 1274
Lilongwe
Malawi

7th March, 2023

The In-charge: Fistula Centre

Dear Sir/Madam

PERMISSION LETTER TO CONDUCT ACADEMIC RESEARCH STUDY AT LILONGWE DISTRICT

The bearer of this letter is **Dr Khumbo Jere** - Principal Investigator from University of Cape Town has been granted a permission to conduct academic research study at Lilongwe District Health Office facility on:-

"Obstetric Fistula in Malawi: Preparedness for the management of Obstetric Fistula in Malawi (A review of trends between 2013-2023)"

Any assistance rendered would be appreciated.

LILONGWE DISTRICT HEALTH OFFICE
07 MAR 2023
DISTRICT MEDICAL OFFICER
P.O. BOX 1274, LILONGWE

Duncan Banda
For: DIRECTOR OF HEALTH AND SOCIAL SERVICES

Appendix 3: Links to databases

1.(Malawi Demographic Health Survey)

Data Access: Available online through MEASURE DHS at https://dhsprogram.com

2. **Malawi Multiple Indicator Cluster Survey (MICS) 2019–2020**

MICS: available online **Data Access:** Freely accessible via UNICEF at

https://mics.unicef.org

3. Malawi **Master Health Facility**

List available at

https://documents1.worldbank.org/curated/en/496011611551081262/pdf/Malawi-Master-Health-Facility-

4.Malawi Spatial Data Platform and OpenStreetMap.

https://www.masdap.mw

Appendix 4: Data Capture Sheet Used in the Fistula Data base

FREEDOM FROM FISTULA FOUNDATION- BWAILA HOSPITAL

PATIENT DEMOGRAPHICS

Date: ___/___/___(D/M/Y)

Name_____ Date of birth_____ (D/M/Y)

Age _____ ☐ DK(99) Area #____ ☐ N/A(98) ☐ DK(99) Village _____ ☐ N/A(98) ☐ DK(99)

District _____☐ N/A(98) ☐ DK(99) Traditional authority _____☐ N/A(98) ☐ DK(99)

Country of residence: ☐ Malawi(0) ☐ Mozambique(1) ☐ Zambia(2) ☐ Other(8)_____ ☐ DK(9)
Tribe ☐ Yao(0) ☐ Chewa(1) ☐ Lomwe(2) ☐ Tumbuka(3) ☐ Tonga(4) ☐ Sena(5) ☐ Nkonde (6)
☐ Ngoni(7) ☐ None(8) ☐ Other(96) _____☐ N/A(98) ☐ DK(99)
Address/landmarks _____ Telephone _____

Village chief _____☐ N/A(98) ☐ DK(99) Referred by: ☐ Radio(0) ☐ Relative/friend(1)
☐ Health facility(2) ☐ TV station(3) ☐ Former patient(4)
Popular neighbor_____☐ N/A(98) ☐ DK(99) Name: _____☐ N/A(98) ☐ DK(99)

Nearest primary school and/or church _____☐ DK(99)

Nearest health center _____ ☐ DK(99)

Religion: ☐ Christian(0) ☐ Muslim(1) ☐ Traditional(2) ☐ None(3) ☐ Other_____(96) ☐ DK(99)
Residence: ☐ Urban(0) ☐ Rural(1) ☐ DK(9)

Living arrangements
☐ Living alone(0) ☐ Living with husband(1)
☐ Living with family/friend(2) ☐ DK(9)

Marital Status:
☐ Single/Never married(0) ☐ Divorced(3)
☐ Married(1) ☐ Widowed(4)
☐ Separated(2) ☐ DK(9)

If patient was ever-married, age at first marriage?
_____ years ☐ Never married(98) ☐ DK(99)

If patient was ever-married, is she still married to her first husband? ☐ Yes(0) ☐ No(1) ☐ DK(99)

Education completed:☐ None(0) ☐ S1-S7(1) ☐ Secondary or more(2) ☐ S8(3) ☐ DK(9)

Roof type:
☐ Grass/None(0) ☐ Other_____(6)
☐ Metal/Wood/Cement(1) ☐ DK(9)
☐ Palm/Cardboard(2)

What does she do for a living (occupation):
☐ Peasant Farmer(0) ☐ Large Business Owner(7)
☐ Commercial farmer(1) ☐ Small Business Owner(8)
☐ Driver/Conductor(2) ☐ Casual Laborer(9)
☐ Student/Pupil(3) ☐ Child/Baby(10)
☐ Unemployed(4) ☐ Other(96)_____
☐ Civil Servant/Teacher(5) ☐ DK(99)
☐ Housewife/Caretaker(6)

NEXT OF KIN Name _____ Relationship _____

Telephone _____ Form completed by: _____

Patient Name: _____
Patient Record #:
