Neonatal transport practices and feasibility of Kangaroo Mother Care transport in Ghana.

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A thesis submitted in partial fulfilment of the requirements of

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for the degree of Doctor of Philosophy

May 2025

Candidate Declaration

I hereby declare that:

1. I have not been enrolled for another award of the University, or other academic or professional organisation, whilst undertaking my research degree.

2. None of the material contained in the thesis has been used in any other submission for an academic award.

3. I certify that this thesis is my own work. The use of all published or other sources of material consulted has been properly and fully acknowledged.

4. The work undertaken towards the thesis has been conducted in accordance with the SHU Principles of Integrity in Research and the SHU Research Ethics Policy, and ethics approval has been granted for all research studies in the thesis.

5. The word count of the thesis is approximately 42,000, with an additional 20,000 words within the published/submitted articles.

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Abstract

Background

Low- and middle-income countries (LMICs) carry a disproportionate burden of global neonatal health challenges, accounting for over 95% of low birth weight (LBW) neonates and 50-80% of neonatal deaths. Fragile health systems worsen this crisis, with shortages of ambulances and dedicated referral teams forcing vulnerable neonates into unsafe transfers, often worsening their condition before reaching specialised care. Kangaroo Mother Care (KMC) is an evidence-based, life-saving intervention defined by the World Health Organization (WHO) by its core components: early and prolonged skin-to-skin contact, exclusive breastfeeding, and a supported continuum of care from hospital initiation to post-discharge follow-up. While KMC holds the potential to improve safety during neonatal transport, its application in this context is limited. This thesis advocates integrating KMC principles into existing neonatal transport protocols to reduce risks and lower mortality among high-risk neonates.

Aim

The primary objective of this thesis was to explore the feasibility of using KMC for neonatal transfer in a limited resource setting using available modes of transport.

Methods

Following a systematic literature review, a convergent parallel mixed-methods study was conducted. The quantitative component consisted of a non-randomised cluster feasibility study, comparing the inter-facility transfer of preterm/LBW infants using either KMC or conventional methods across eight peripheral units in Ghana to the Cape Coast Teaching Hospital. Concurrently, a qualitative component captured stakeholder perspectives via semi-structured interviews with mothers and healthcare professionals. The two data sets were analysed separately and subsequently integrated through triangulation to form a cohesive narrative of the intervention's implementation.

Results

The systematic review identified systemic deficiencies—poor planning, resourcing, and coordination—in neonatal transport across Sub-Saharan Africa, noting a lack of studies on evidence-based, low-cost transport interventions. The quantitative findings demonstrated that KMC during transport is safe, with no adverse events, and potentially leads to improved neonatal arrival temperatures and reduced mortality upon discharge. Qualitatively, mothers highly accepted KMC transport, reporting empowerment and a stronger infant bond, despite some concerns about physical discomfort. The integration of both study phases revealed four critical themes for scaling: clinical benefits, social and cultural context, KMC as an empowerment intervention, and the necessity for education and awareness. In contrast, the conventional care cohort underscored persistent systemic transport inadequacies, advocating for enhanced ambulance availability, accompanied transfers, and improved communication to improve neonatal outcomes in Cape Coast.

Conclusion

KMC transport using available transport methods is feasible in Sub-Saharan Africa. Mothers and healthcare professionals largely supported the intervention. To advance large-scale research and implementation, a more inclusive strategy that educates mothers, healthcare professionals, and policymakers is essential.

Original contribution

This research contributes original knowledge by exploring the practicality of implementing an evidence-based, cost-effective intervention—specifically Kangaroo Mother Care—within the neonatal transport process in Sub-Saharan Africa. Additionally, a previously unreported study in this subregion confirms the intervention as both feasible and acceptable to mothers and healthcare professionals. Its feasibility is demonstrated through the utilisation of existing transport options, in the context of inadequate ambulances and the absence of specialised neonatal transport teams.

Acknowledgements

I wish to convey my profound gratitude to my Director of Studies, Professor Hora Soltani, whose mentorship transcended academic pursuits and extended into personal guidance, offering comfort and motivation during challenging periods. Furthermore, I would like to acknowledge my supervisor, Dr Frankie Fair, for her unwavering support and insightful critiques throughout my research journey. Her constructive feedback and invaluable suggestions have significantly enhanced the quality of this dissertation.

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Abbreviations used within the thesis

APGAR	Appearance, Pulse, Grimace, Activity, Respiration
Ca-TRIPS	California transport risk index of physiologic stability
CCTH	Cape Coast Teaching Hospital
CCTHERC	Cape Coast Teaching Hospital Ethical Review Committee
CHAG	Christian Health Association of Ghana
CHPS	Community-Based Health Planning and Services
CHW	Community health workers
CI	Confidence interval
COREQ	COnsolidated criteria for REporting Qualitative research
CRTs	Cluster-randomised trials
DHMT	District Health Management Team
ELCS	Elective caesarean section
EMCS	Emergency caesarean section
ENAP	Every newborn action plan
ERC	Ethical Review Committee
ESRC	Economic and Social Research Council
FCC	Family-centred care
FCGP	Fellow of the Ghana College of Physicians
FRCPCH	Fellow of the Royal College of Paediatrics and Child Health
g	Gram
GEE	Generalised estimating equations
GHS	Ghana Health Service
GH¢	Ghana cedi
GLMM	Generalised linear mixed effect models
GRAMM's	Good reporting of a mixed methods study
GSS	Ghana Statistical Service
HIV	Human immunodeficiency virus
ICF	International Centre for Policy Studies

IVH	Intraventricular haemorrhage
JSS	Junior Secondary School
Kg	Kilogram
Km	Kilometre
KMC	Kangaroo Mother Care
LBW	Low birth weight
LMICs	Low- and middle-income countries
LPG	Liquefied petroleum gas
MDGs	Millennium Development Goals
MgSO4	Magnesium sulphate
MMAT	Mixed Methods Appraisal Tool
MOH	Ministry of Health
NETSCC	NIHR evaluation, trials and studies coordinating centre
NHIR	National Institute for Health and Care Research
NHIS	National health insurance scheme
NICU	Neonatal intensive care unit
NMR	Neonatal mortality rate
NVD	Normal vaginal delivery
PHC	Primary health care
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PRISMA-P	Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Protocol
PROM	Premature rupture of membranes
QUAL	Qualitative
QUAN	Quantitative
RCTs	Randomised-controlled trials
RHMT	Regional Health Management Team
RR	Risk ratio
SD	Standard deviation
SDGs	Sustainable Development Goals

SDHMT	Subdistrict Health Management Team
SGA	Small for gestational age
SHU	Sheffield Hallam University
SNAPPE	Score for neonatal acute physiology with perinatal extension-II
SSA	Sub-Saharan Africa
SSS	Senior Secondary School
TBA	Traditional birth attendant
TROTRO	Local name for a public bus in Ghana
UCC	University of Cape Coast
UCC-SMS	University of Cape Coast, School of Medical Sciences
UHC	Universal health coverage
UNICEF	United Nations Children's Fund
US$	United States dollar
WHO	World Health Organization
YR	Year

Preliminaries

0.1 Article-based thesis

This thesis is presented in an article-based format. The guidance provided by Sheffield Hallam University for an article-based thesis stipulates that it generally encompasses three to five publications; however, this numerical range serves as a guideline rather than a rigid requirement. Typically, the outputs should either be published, accepted for publication, or submitted to publishing outlets for peer review. At the time of submission, an article-based thesis must contain a minimum of one article that has undergone a comprehensive peer review and has been accepted for publication. An article-based thesis usually includes an elucidation of the research question, a background section encompassing the pertinent literature relevant to the research topic, and the methodology employed in the research programme. Following the presentation of the articles on which the thesis is based, the findings from the individual research components are integrated and discussed, including an exploration of the original contribution to the knowledge gained from the research.

This article-based thesis comprises two articles that have been published in peer-reviewed journals by the time of submission, along with one article that is currently under review. These articles report distinct yet interconnected aspects of the research programme. The articles are reproduced within this thesis, supplemented by a narrative.

0.2 Research outputs

Articles

Okai E, Fair F, Soltani H. Neonatal transport practices and effectiveness of the use of low-cost interventions on outcomes of transported neonates in Sub-Saharan Africa: A systematic review and narrative synthesis. Health Science Reports. 2024 Mar;7(3):e1938.

Okai E, Fair F, Konadu HD, Darteh EK, Soltani H. Feasibility of the use of Kangaroo Mother Care in the transfer of preterm and low birth weight infants: a two-arm non-randomised controlled cluster feasibility study of neonatal transport in Cape Coast, Ghana. BMC *Pediatrics*. 2024 Dec 28;24(1):842.

Okai E, Fair F, Konadu HD, Prince A, Ntim E, Darteh EK, Soltani H. Acceptability of Kangaroo Mother Care (KMC) in neonatal transport: A qualitative study on mothers' and healthcare professionals' perspectives on KMC transport in Ghana**.**

(Currently under review for publication in BMC *Pediatrics*)

Chapter 1: Introduction

1.1 Introduction

Safe neonatal transport is an evolving process in most low- and middle-income countries (LMICs), with poor transport practices reported as a contributing factor to increased infant mortality (1,2). In developed countries, neonatal emergency transport teams organise neonatal transport. These teams are designed to ensure uninterrupted neonatal care during the transfer process, which is essential to maintaining haemodynamic stability in transported neonates.

An effective neonatal transport service consists of several essential components, including pre-referral care, access to emergency transport, and continuity of care between healthcare facilities (3). In many developing countries, however, challenges within the referral and transportation systems—such as inadequate means of transportation, deficient communication between facilities, poor documentation, and insufficient monitoring—have been recognised as significant factors obstructing progress in reducing neonatal mortality (4).

Globally, neonatal mortality has decreased by 44% since 2000. However, nearly half (47%) of all deaths among children under five occur during the neonatal period. Sub-Saharan Africa (SSA) accounts for 57% of under-five mortality and has the highest neonatal mortality rate (NMR) worldwide, at 27 deaths per 1000 live births. Central and South Asia follows, with an NMR of 21 per 1000 live births (5). The United Nations has adopted 17 Sustainable Development Goals (SDGs), which aim to reduce the under-5 mortality rate to 25 or fewer deaths per 1000 live births by 2030 and to reduce NMR to 12 or fewer deaths per 1000 live births (6,7). Already, 126 nations have achieved the target of reducing NMR to 12 or fewer

deaths per 1000 live births. However, if current trends continue, 63 nations, mainly LMICs, will not reach this target (8). To reach this target, most nations currently falling short will need to double their pace of advancement.

Ghana, with a population of 30.8 million and a rapidly urbanising, youthful population (9), is among the countries needing to accelerate progress towards the under-5 and neonatal mortality targets (10). The NMR in Ghana decreased from 29 per 1000 live births in 2014 to 17 per 1000 live births in 2022 (11). According to the 2023 Ghana Demographic and Health Survey, 86% of live births and stillbirths occur in health facilities. Furthermore, 88% of these births were attended by a skilled provider, representing an increase from 76% in 2014 (11). Delivery by skilled birth attendants, health facility deliveries, and family planning are essential interventions that reduce maternal and neonatal morbidity and mortality. However, the proportion of deliveries attended by skilled personnel remains low, especially in SSA, where skilled birth attendants assist with only half of the deliveries (12).

Over the past two decades, Ghana has implemented numerous initiatives aimed at reducing maternal and infant mortality rates. One such reproductive health policy adopted in Ghana is the Community-Based Health Planning and Services (CHPS) programme. The Ministry of Health (MOH), in conjunction with the Ghana Health Service (GHS), initiated the CHPS programme in 2000 to enhance accessibility to maternal and child health services at the community level (13–15). The operationalisation of the CHPS initiative ensured universal access to maternal and child healthcare services in rural Ghana (14). CHPS compounds served as the initial access point for primary healthcare within communities. Trained community health nurses with basic obstetric skills screened pregnant women, provided

antenatal care, assisted during labour, and referred women to a more advanced health centre for further facility management (15).

The government of Ghana introduced the Free Maternal Health Care Policy in 2003 to reduce financial barriers to access delivery services and to reduce the maternal mortality rate (16). In 2008, the policy was integrated into the ongoing National Health Insurance Scheme (NHIS), which began in 2005. The Free Maternal Health Care Policy under the NHIS is a comprehensive maternal benefits package that includes six free antenatal visits, emergency outpatient visits, free facility delivery for all complicated deliveries, and two postnatal visits within six weeks. It waives the NHIS premium and registration fees, covering the pregnant woman for one year and the newborn infant for the first three months of life (17,18).

The Free Maternal Health Care Policy contributed significantly to the decline of maternal and infant mortality in Ghana between 2000 and 2015, positioning the country favourably relative to other countries in SSA and illustrating the potential of strategic health initiatives to effect meaningful change (19). Despite the availability of complementary maternal healthcare, including delivery services for pregnant women and their infants in Ghana, disparities in the provision of these services persist. This is predominantly attributable to the lack of specialised care in specific healthcare facilities, particularly in rural and peri-urban areas of Ghana.

Specialised neonatal services remain a significant challenge in many LMICs, including Ghana, with the few existing services concentrated in urban areas. This deficiency in neonatal critical care services often compels caregivers to transport critically ill neonates across long

distances, frequently holding them wrapped in their arms. The admission temperature of newborns across all gestational ages is a strong predictor of morbidity and mortality, particularly for preterm and low birth weight infants (20,21). A dedicated neonatal transport service using ambulances and transport incubators helps maintain thermoregulation and physiological stability in transported newborns. However, this service is costly and often unavailable in many developing countries, including Ghana (22,23).

Kangaroo Mother Care (KMC), also known as skin-to-skin contact, is an effective method of care that utilises the parent's body heat to regulate the baby's body temperature. This simple, cost-effective, evidence-based intervention has been demonstrated to reduce neonatal mortality and the risk of infection in low birth weight infants, offering hope for improved neonatal care (24). A Cochrane review of 16 randomised-controlled trials (RCTs), encompassing 2,518 low birth weight (LBW) infants, compared KMC to conventional care, as well as early-onset (within 24 hours of birth) to late-onset KMC (beginning 24 or more hours after birth). The analysis found that, at discharge or 40–41 weeks' postmenstrual age, KMC was associated with significantly reduced risks of mortality (RR 0.60, 95% CI 0.39–0.93), nosocomial infection/sepsis (RR 0.42, 95% CI 0.24–0.73), and hypothermia (RR 0.23, 95% CI 0.10–0.55), alongside a shorter mean hospital stay (mean difference -2.4 days, 95% CI -4.1 to -0.7). These benefits persisted at the latest follow-up, with KMC linked to lower mortality (RR 0.68, 95% CI 0.48–0.96) and severe infection/sepsis (RR 0.57, 95% CI 0.40–0.80). Furthermore, KMC demonstrated positive effects on infant growth, breastfeeding rates, and mother–infant attachment (25).

In settings with limited resources, KMC is considered a highly cost-effective intervention because it is easy to implement, requires minimal equipment, and significantly decreases

the need for expensive incubator care, while still providing substantial benefits to preterm and low birth weight infants, including increased survival rates and reduced risk of infection (26). This makes it a valuable alternative to conventional care methods. The use of KMC within neonatal units is well documented and, until recently, has been reserved for stable preterm and LBW neonates (27).

The integration of KMC into neonatal transport protocols offers a significant opportunity to overcome the substantial limitations associated with inadequate incubator transfer in many developing countries. Research conducted on kangaroo positioning during neonatal ground ambulance transport by Van den Berg *et al.* (28), Sontheimer *et al*. (29), and Lundqvist *et al*. (30) in Sweden, along with one study from a resource-limited setting by Zamora *et al*. in the Philippines (31), indicates consistent therapeutic benefits.

However, studies on KMC transport in SSA are limited, and there is no policy directive promoting its use. Neonatal transport in the region is mainly carried out by caregivers themselves, with little attention paid to care during transit. Investigating the safe application of KMC in transferring these newborns could help reduce neonatal mortality and morbidity in the region.

1.2 Aims and objectives

The primary objective of this research programme is to examine the question,

Is the implementation of KMC in neonatal transport feasible in Ghana?

To consider this question, the research will focus on three specific objectives:

- Establish what is known in the current research literature regarding neonatal transport practices in Sub-Saharan Africa.
- Conduct a non-randomised cluster feasibility study to assess the feasibility of employing KMC in the transport of preterm and low birth weight neonates in Ghana.
- Explore the perspectives of caregivers and healthcare professionals on using KMC for neonatal transport in Ghana.

1.3 Overview of the research programme

This thesis presents original research conducted in an article-based format. It comprises three research articles—two published and one currently under review for publication—in reputable international peer-reviewed scientific journals. The overarching findings of the research are synthesised and discussed, including the unique contribution this work makes. Figure 1 provides an overview of the research programme.

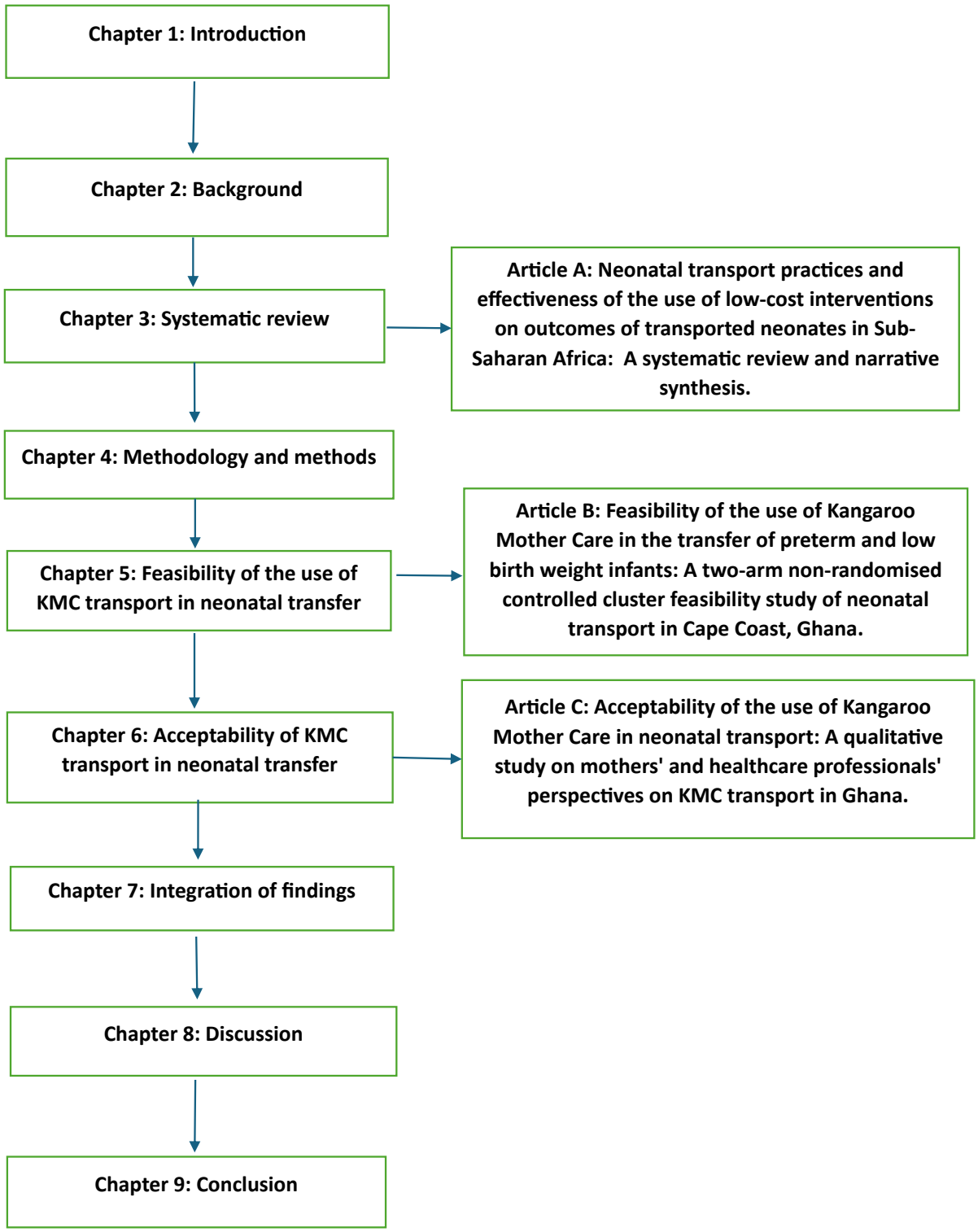

Figure 1: Overview of the research programme and how it is presented in this thesis

1.4 Thesis structure

Chapter 1 introduces the thesis and provides a brief rationale, the aims and objectives of the research programme, and an overview of the included studies. It also provides an overview of the chapters within the thesis.

Chapter 2 comprehensively reviews the relevant background literature and identifies any existing gaps. It provides background data on Ghana's health statistics about neonatal and infant mortality, as well as some background on Kangaroo Mother Care.

Chapter 3 contains Article A, "Neonatal transport practices and effectiveness of the use of low-cost interventions on outcomes of transported neonates in Sub-Saharan Africa: A systematic review and narrative synthesis", which was accepted for publication in *Health Science Reports* in March 2024. It provides a detailed summary of studies on neonatal transport in Sub-Saharan Africa and the cost-effective interventions employed.

Chapter 4 details the methodology and methods that underpin the research programme and discusses the theoretical perspectives, philosophical assumptions, and justification for choosing a mixed-methods approach.

Chapter 5 contains Article B, "Feasibility of the use of Kangaroo Mother Care in the transfer of preterm and low birth weight infants: A two-arm non-randomised controlled cluster feasibility study of neonatal transport in Cape Coast, Ghana", which was accepted for publication in *BMC Pediatrics* in December 2024. It reports on the outcome of preterm and low birth weight infants transferred using either KMC or conventional care in a feasibility study conducted in Ghana.

Chapter 6 contains Article C, "Acceptability of the use of Kangaroo Mother Care in neonatal transport: A qualitative study on mothers' and healthcare professionals' perspectives on KMC transport in Ghana", which at the time of submission of the thesis was under review for publication in *BMC Pediatrics*. It reports on the acceptability of employing KMC in neonatal transport by exploring the perspectives of healthcare professionals and mothers who consented to use the intervention in the study. The chapter also highlights mothers' perspectives within the conventional care group regarding the neonatal transport process and suggests ways to enhance neonatal care in the unit.

Chapter 7 presents the integrated findings across the different aspects of the research programme, including the systematic review and the quantitative and qualitative phases, and develops overarching themes.

Chapter 8 summarises the key research findings and highlights the programme's strengths and limitations.

Chapter 9 concludes the thesis by reviewing the aims and objectives of the introduction. It highlights the new knowledge generated by this research programme and outlines its implications for practice, policy development, and future research.

1.5 Anticipated contribution of new knowledge

This research programme contributes to the existing body of literature on neonatal transport in Sub-Saharan Africa by exploring the use of a cost-effective intervention in the neonatal transfer process in a manner not previously explored in the subregion. The work further generates new knowledge about the perspectives of mothers and healthcare professionals on how such a cost-effective intervention can be supported for scaling up, if it

is acceptable, to improve the outcomes of neonates who require transfer to specialist care centres.

Chapter 2: Background

2.1 Introduction

This chapter offers a comprehensive overview of the magnitude of neonatal mortality in Sub-Saharan Africa and Ghana. It further summarises Ghana's healthcare system and initiatives aimed at enhancing maternal and infant health outcomes. The chapter concludes with an analysis of neonatal transfers and Kangaroo Mother Care and provides a justification for implementing KMC during neonatal transport in resource-constrained environments.

2.2 Scale of the problem

Globally, substantial progress has been achieved in child survival since the inception of the Millennium Development Goals (MDGs) aimed at tackling the indignity of poverty and its negative consequences, including child mortality, over two decades ago (32). Progress in reducing neonatal mortality has, however, lagged behind the overall decline in deaths among children under the age of 5 years. Between 1990 and 2022, there were 2.3 million neonatal deaths worldwide, down from 5 million deaths in 1990. Nevertheless, neonatal mortality decreased more slowly during this period compared to post-neonatal under-5 mortality (5).

Since 2000, neonatal mortality has declined by 44%. The neonatal period (the first 28 days of life) accounted for nearly half (47%) of all deaths among under-5 children in 2022 (5).
In 2022, only 30% of global live births occurred in Sub-Saharan Africa, yet this region accounted for 57% (2.8 million) of all under-5 mortalities worldwide. Additionally, Sub-Saharan Africa exhibited the highest NMR globally, with 27 deaths per 1000 live births, followed by Central and South Asia, which experienced a rate of 21 deaths per 1000 live births (5).

Globally, the primary causes of neonatal mortality remain prematurity, congenital abnormalities, perinatal infections, and intrapartum-related complications, including birth asphyxia and trauma (5). Achieving the SDG child survival targets within the agreed timeline requires continued and enhanced efforts to scale up proven life-saving interventions. The SDG Goal 3.2 target aims to end preventable deaths of newborns and children under 5, with all countries striving to reduce neonatal mortality to 12 or fewer per 1000 live births and under-5 mortality to 25 or fewer per 1000 live births by 2030 (6). This translates to 97.5% of all newborns living beyond the first five years, regardless of where they were delivered. Currently, the world is far from its 2030 target (10).

2.2.1 Definitions

A neonate is a child less than 28 days old. This stage carries the highest mortality risk for infants, with 17 deaths per 1,000 live births reported worldwide in 2022. This figure is a 53% reduction from the 37 deaths per 1,000 live births reported in 1990 (33). In comparison, the risk of dying after the first month but before the first birthday is estimated at 11 per 1000 live births, whereas the risk of dying between the ages of 1 and 5 years is estimated at 9 per 1000 in 2022 (33). Despite a substantial decline in its neonatal mortality rate—from 60 to 21 per 1000 live births between 1965 and 2022—Ghana's progress lags behind global benchmarks. The current rate, while favourable compared to the African average of 26 per 1000 live births, exceeds the global average of 17 per 1000 live births (Figure 2) (34) and falls short of SDG objectives.

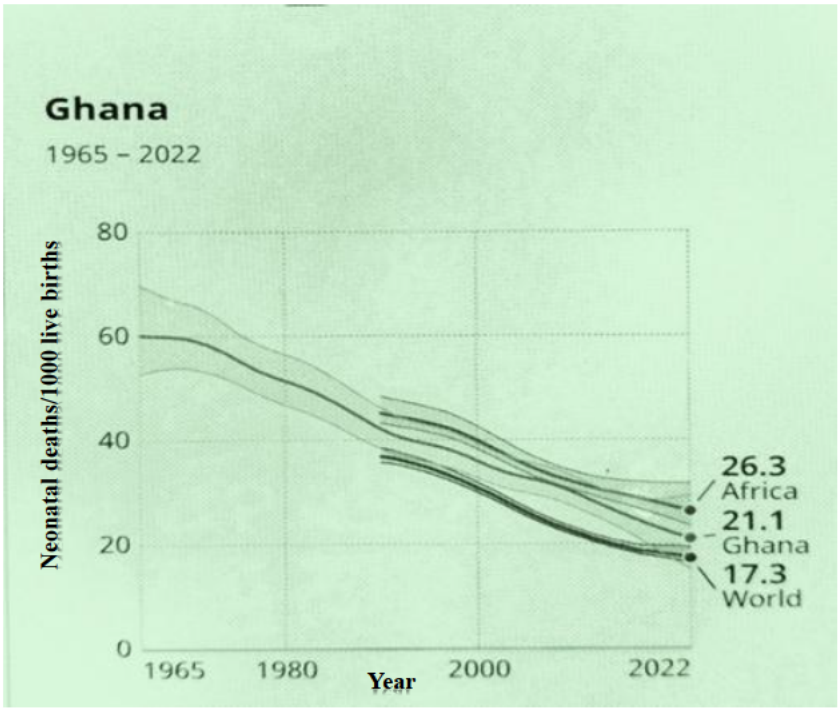

Figure 2: Comparison of global neonatal mortality rates in Ghana and Africa. Source: who.int/data; https://data.who.int/indicators/i/E3CAF2B/A4C49D3 (34)

Neonates are classified by gestational age: term if born alive between 37 and 42 completed weeks, and preterm if born alive before 37 weeks. Preterm births are further divided into categories: extreme preterm (<28 weeks), very preterm (28 to <32 weeks), and moderate to late preterm (32 to 37 weeks) (35). For pragmatic reasons, in 1963, Battaglia *et al.* proposed a classification system for neonates that incorporated not only gestational age but also weight, subsequently publishing detailed birth-weight nomograms by gestational week (36). In 1976, the 29th World Health Assembly adopted the definitions currently in use. The World Health Organization (WHO) defines low birth weight as a birth weight of less than 2,500 g (up to and including 2,499 g). The WHO further classifies low birth weight into very low birth weight (less than 1,500 grams) and extremely low birth weight (less than 1,000 grams). Low birth weight predominantly results from preterm birth, intrauterine growth restriction, also referred to as foetal growth restriction, or a combination of both factors.

Babies born with birth weights below the 10th percentile for their gestational age are referred to as small for gestational age (SGA) (37). Although LBW is common in SGA babies, the two conditions are not interchangeable. SGA can result from several factors, such as (a) being constitutionally small and (b) intrauterine growth restriction, which indicates a pathological restriction of the genetic growth potential (37). Although some babies are naturally small, their growth is proportionate to their mothers' size and ethnicity. A study by Louis *et al*. on racial/ethnic standards for foetal growth in the United States reported that many minority mothers' foetuses may develop normally, but they tend to be smaller than their Caucasian counterparts due to environmental and genetic influences (38).

2.2.2 Concerns associated with preterm and LBW infants

Preterm and LBW babies face substantially higher risks of mortality and adverse outcomes compared to babies born at term, and these are currently the leading causes of neonatal mortality (39,40). The risks of mortality and morbidity increase with the degree of prematurity, with babies born extremely preterm at the highest risk, followed by those born very preterm, and then those born moderate to late preterm (39). Prematurity represents the predominant cause of mortality among under-5 children worldwide (41). Furthermore, preterm infants face additional risks due to the immaturity of several organ systems, resulting in a variety of morbidities, including intracranial haemorrhage, sepsis, respiratory distress, blindness, gastrointestinal disorders, and cerebral palsy (42).

LBW is an important public health indicator of poverty, nutrition, maternal health, and healthcare provision (43,44). The risk of death is more than 20 times higher for neonates weighing less than 2,500 g at birth. LBW also increases the risk of chronic illnesses, such as diabetes and cardiovascular disease, delayed language development, long-term neurological

impairment, and poor academic performance in later life (43). Furthermore, economic studies conducted in low-income settings suggest that reducing the prevalence of LBW will yield significant savings for households and the healthcare system (44). A study conducted by Sicuri *et al*. in southern Mozambique estimated the costs incurred by the health system, households, and the Disability-Adjusted Life Years attributable to deaths associated with low birth weight infants (45). The study utilised the incremental number of hospital admissions for LBW infants compared to those of non-LBW infants to compute excess morbidity-related costs. These costs encompassed routine medical care, including additional days of hospitalisation following delivery and weighing visits, as well as costs associated with excess morbidity, such as hospitalisations and outpatient visits. The findings indicated that the average household expenditure for standard medical treatment of a LBW infant in Mozambique, encompassing both direct and indirect costs, was US$23.04. Furthermore, a 100 g increase in birth weight was associated with a 53% reduction in these costs. The direct and indirect household costs associated with hospital admissions were US$8.50 (95% confidence interval [CI]: 6.33-10.72). For the 3,322 live births recorded within the study area over one year, the health system costs attributable to LBW—covering routine healthcare and excess morbidity—amounted to US$169,957.61 (95% CI: 144,900.00; 195,500.00), while the Disability-Adjusted Life Years totalled approximately US$2,746.06 (45).

Globally, an estimated 15–20% of all births, or over 20 million newborns annually, are low birth weight infants. Low- and middle-income countries disproportionately bear a higher burden, with over 95% of the world's LBW infants being born in LMICs, and 50% to 80% of these births contributing to global neonatal mortality (46). There are significant global and

regional variations in LBW rates. An estimated 6% of infants are born LBW in East Asia and the Pacific, 13% in Sub-Saharan Africa, and up to 28% in South Asia (46,47).

Worldwide, preterm birth rates have remained relatively stable over the past decade despite greater emphasis on routine health data collection and the rise in facility-based births. In 2020, an estimated 13.4 million newborns were born before 37 weeks (9.9% of all births), compared to 13.8 million in 2010 (9.8% of all births [9.0–11.0]) globally (39). Southern Asia (26.8%) and Sub-Saharan Africa (28.7%) accounted for almost 65% of all preterm births worldwide, despite accounting for 55.6% of all livebirths (39).

2.3 Health service delivery and referral systems in LMICs

The egalitarian perspective of healthcare as a basic human right forms the basis of Universal Health Coverage (UHC), following in the footsteps of previous unifying ideas such as Health for All (48) and the Alma-Ata declaration (49). According to UHC's vision, all citizens should benefit from a robust and effective healthcare system that encompasses preventive and curative care, affordable access to medication, and sufficient healthcare personnel.

Universal Health Coverage constitutes a comprehensive health framework that ensures that all individuals and communities have access to the full range of quality health services necessary, including health promotion, prevention, treatment, rehabilitation, and palliative care, without experiencing financial hardship (50).

These services can only be provided by competent healthcare systems with optimally skilled healthcare personnel who are fairly distributed, sustainably financed, and supported by a robust healthcare infrastructure. Improving human health and well-being (SDG Goal 3) is

central to achieving the Sustainable Development Goals and is vital for meeting targets related to neonatal care. This goal has a target to-

> ***"END ALL PREVENTABLE DEATHS UNDER 5 YEARS OF AGE**: By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-five mortality to at least as low as 25 per 1,000 live births."* Target 3.2 (6)

LMICs with reported high neonatal mortality have significant challenges in almost all the health system building blocks defined by the WHO (51), as shown in Figure 3.

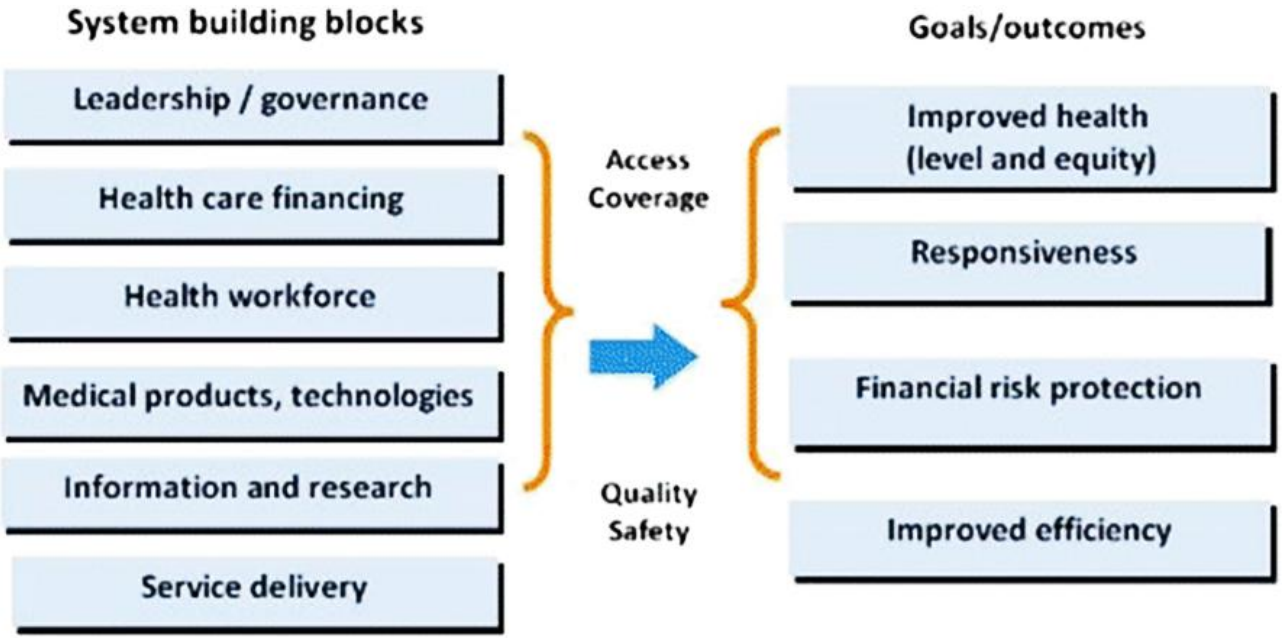

Figure 3: The WHO health systems framework (51)

Given the resources and conditions at hand, a health workforce that performs well, works fairly and efficiently, and is responsive can achieve the best possible health outcomes. Readily available access to skilled attendance at birth remains a significant challenge in many resource-constrained settings (52). Additionally, neonatal care in many resource-constrained settings currently faces enormous challenges. Newborn inpatient care is facility-based care

of newborns that focuses on both the treatment and prevention of infections and other neonatal complications. It is typically provided across three levels (Figure 4) and includes two cornerstone components: KMC and sepsis case management (53,54).

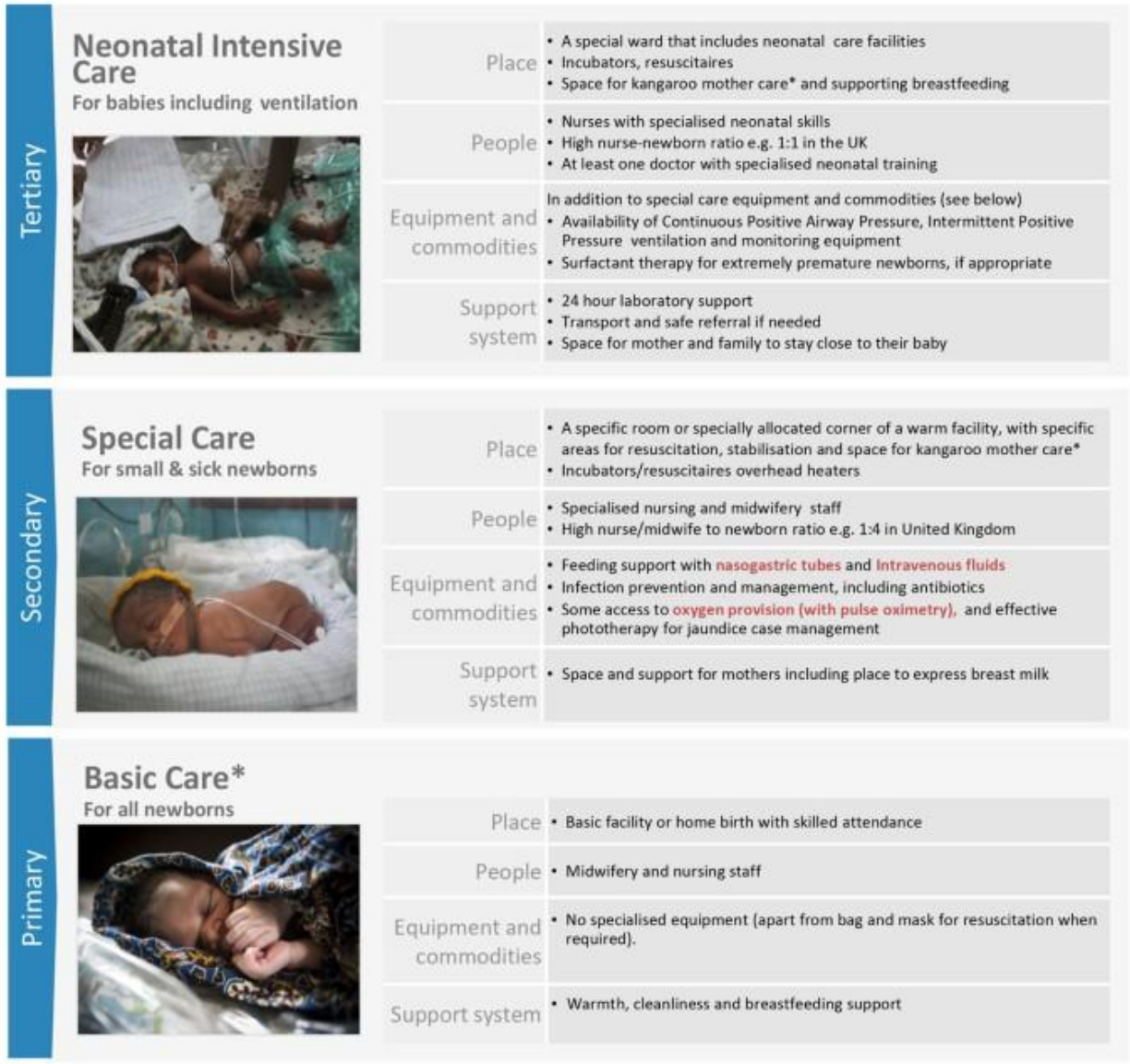

Figure 4: Inpatient care of small and sick babies, showing health system requirements by level of care. Red text signifies a tracer indicator for bottleneck tool analysis. *See Vesel *et al.* (53) Kangaroo Mother Care, Enweronu-Laryea *et al.* (55) Basic newborn care and resuscitation, and Simen-Kapeu *et al.* (54) Neonatal sepsis. Neonatal intensive care, image source: Getty Images/Save the Children. Special care for small and sick newborns, image source: Ian Hurley/Save the Children. Basic care for all newborns, image source: Jonathan Hyams/Save the Children.

While all three levels of care will be accessible in a properly functioning healthcare system, many LBW and preterm infants can be cared for in special care units (56) without the need for higher-level neonatal intensive care. However, over 75% of infants born in Southern Asia and Sub-Saharan Africa still cannot access necessary special care when needed (Figure 5).

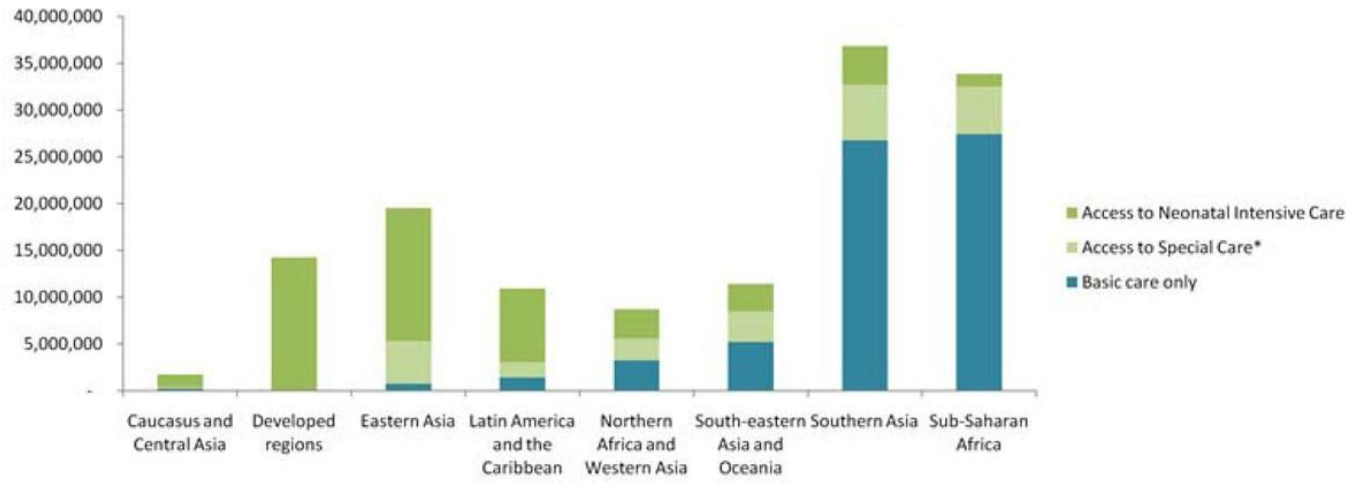

Figure 5: Estimated coverage of neonatal care by region and level of care. Y-axis: Births/year. *By Special Care Baby Unit, this is the highest level of care available (i.e., no neonatal intensive care). Data source: Adapted from Beyond Newborn Survival (57)

Reduced mortality and better maternal and neonatal health outcomes are linked to high-quality intrapartum and early postpartum care at a medical facility and delivery under the guidance of qualified staff (58,59).

2.3.1 Facility deliveries and maternal and neonatal outcomes

The superior health outcomes for parturient women delivered in facilities with basic and comprehensive emergency obstetric care are well established. However, in SSA, the utilisation of these facilities is constrained by challenges of availability, quality, and accessibility, driven by sociocultural factors, financial constraints, and insufficient healthcare investment (60,61). The equivocal relationship between facility delivery and early neonatal

mortality further highlights that the mere presence of a facility is insufficient; the quality and specific context of care are paramount determinants of its effectiveness (62).

The pattern of health facility deliveries varies within clusters or communities, as well as within countries. At least half of all births in developing countries occur without skilled birth attendants (61), and nearly three-quarters (73.3%) occur in rural areas (73). A recent study examining data from 58 demographic and health surveys conducted in 29 Sub-Saharan African nations between 1990 and 2015 found that, on average, facility-based deliveries increased after 2010 compared to surveys conducted since the 1990s (63). Despite notable differences across nations, recent surveys indicate that births are 85% more likely to occur in medical facilities than in earlier surveys. Although these findings regarding improved facility deliveries are encouraging, they have not resulted in a significant decrease in neonatal mortality rates across the region (62). This implies that enhancing newborn health requires consideration beyond the place of birth.

The disparity in health facility delivery results in many neonates in resource-constrained settings being born in environments lacking sufficient resources for newborn care, often in suboptimal and uncertain conditions, necessitating their transfer to better-equipped facilities where appropriate specialised or intensive care can be provided.

According to WHO statistics, about one-third of neonatal deaths occur on the day of birth, with close to three-quarters happening in the first seven days (5). Many of these neonatal deaths result from a lack of contact with the health system or inadequate transfer systems that hinder access to higher-level facilities (64,65). Prompt attention to and referral of sick neonates can significantly help reduce the high mortality rate occurring on the day of birth (66).

2.3.2 Referral systems

Referral systems are crucial for managing the flow of patients from primary to secondary care facilities, which have resources beyond those available at the original location. This is essential for any healthcare system, as it plays a critical role in treating illnesses and improving health outcomes (67). An effective health referral system is essential for saving lives and ensuring that patients receive the best possible care by fostering strong relationships across all levels of the healthcare system (68). A referral is defined as a process in which a health worker at the health system level, who lacks the necessary resources (medications, equipment, and skills) to manage a clinical condition, seeks assistance from a better-equipped facility or one with different resources at the same or higher level to support or take over responsibility for the client's case (67). For a referral to succeed, it is essential that there is geographic access to referral care facilities, availability of referral services, qualified personnel capable of delivering high-quality treatment, reasonably priced services, and the requisite medications, supplies, and equipment (69).

A well-functioning referral system that facilitates continuity of care across healthcare levels is essential to achieving SDG 3. However, in many low- and middle-income countries, referral systems are insufficient and often hindered by structural inefficiencies (70) that negatively impact health outcomes. Among the difficulties facing health referral systems in LMICs are a high number of self-referrals (71), inadequate health information systems for collecting referral data (72), non-compliance with referrals (73), poor road conditions impacting facility access, and inadequate transportation arrangements for emergency referrals (74).

Nakayuki *et al.*, in a systematic review of challenges affecting health referral systems in low- and low-middle-income countries (75), identified four thematic areas that adversely impact referral systems in LMICs (Table 1).

Theme	**Challenges**
Human resource constraints	Lack of staff motivation, limited capacity of healthcare providers, and poor healthcare provided.
Financial constraints	Poor infrastructure and financial issues.
Non-compliance	Non-compliance with the referral system and congestion of patients.
Communication challenges	Limited patient details, lack of coordination, and poor communication.

Table 1: Categorisation of the challenges affecting referral systems. Source: Nakayuki *et al.*(75)

The aforementioned challenges, including a lack of monitoring during the referral process, have been established as factors impeding the stride towards reducing neonatal mortality in developing countries (76). Transferring newborns to a tertiary care centre requires a well-established referral system (77,78), with previous research providing evidence that among transferred newborns, hypothermia, hypoglycaemia, poor perfusion, and hypoxia are linked to higher mortality rates (79–82).

2.4 Neonatal transport

In-utero transfer is the safest and most secure form of transfer; however, the unpredictability of preterm delivery and perinatal illness has created an ongoing need for an effective neonatal transport system (83). Neonates have needed transportation for many years, since it became clinically clear that not all hospitals could provide the necessary care

for a premature or seriously ill neonate. Since the first organised transportation programme (New York Premature Infant Transport Service) was initiated in 1948 by the New York Department of Health in collaboration with regional hospitals (84,85), neonatal transport has been constantly evolving. It has become a vital component of contemporary perinatal care, which is currently regionalised. The concept of regionalisation in perinatology first emerged in the 1960s to effectively manage highly specialised newborn services (86).

Regionalisation in perinatal networks necessitates the following components: (a) acknowledgement of each hospital's capacity to deliver care to mothers and newborns; (b) an efficient system for the identification of high-risk pregnancies and the facilitation of their antenatal transport to facilities with appropriate levels of care; (c) neonatal facilities that are adequately equipped to address all medical needs within the neonatal network, both quantitatively and qualitatively; and (d) an appropriate neonatal transport system (87). Neonatal transport systems are essential for ensuring the safe transfer of newborns who require specialised medical care.

Janati *et al*. conducted a comparative retrospective study of 12 neonatal transport systems across nine developed and developing nations, including the United States of America, Britain, Canada, Australia, Sweden, Scotland, Hungary, India, and China (88). The study employed four selection criteria: (1) the composition of the transport team, (2) the types and organisational structures of transport, (3) the status of neonatal transport systems, and (4) key neonatal health indicators. The results demonstrated that trained nurses served as core personnel in all reviewed systems, supplemented by medical or paramedic staff depending on specific transport protocols. Furthermore, the study found that the efficacy of

these systems depended upon effective regionalisation and appropriate management of transport processes (88).

Establishing a regionalised neonatal transport system with resources tailored to specific needs is vital to ensuring system efficiency and enhancing overall neonatal health outcomes.

2.4.1 Resource allocation in neonatal transport

The objective in neonatal transport is to optimise the use of limited resources by employing appropriate allocation strategies that consider neonatal characteristics. This is vital to ensure that these limited resources are utilised as effectively as possible to maximise the health benefits for this vulnerable population (89). A thorough understanding of neonatal care needs is critical for successful resource allocation, as poor resource allocation leads to suboptimal outcomes and increased disparity (89). These challenges are even more pronounced in developing countries, which may be constrained by limited funding, medical practitioners, and facilities in providing care (89).

In care systems with regionalised neonatal care, establishing sustainable neonatal transport networks is crucial for overcoming these challenges, necessitating strategies that optimise the effective use of existing resources (90). One method already in use is the design and efficient functioning of quality transport teams that follow standardised approaches to safeguarding neonates and team members during transport, as well as supporting parents and family members (91). It involves educating and training healthcare professionals while updating and standardising transport equipment and protocols across various regions.

Comparative studies of neonatal transportation schemes in developed and developing countries demonstrate the need for appropriately targeted resource allocation strategies based on individual country needs and circumstances (88). By exploring successful

structures operating in developed countries and adapting them to local contexts, developing countries can better strategise their resource use to deliver higher-quality, safer transport services for neonates. This entails establishing clear guidelines and practices for the transport teams to follow and providing the necessary support and infrastructure to embed these improvements sustainably (89).

2.4.2 Neonatal transport in LMICs

Improving economic conditions and political stabilisation are facilitating advancements in healthcare in LMICs, with advanced neonatal intensive care units being established to provide medical care to sick newborns delivered either at home, at primary health centres, or at less equipped birthing units within their catchment areas; however, the utilisation of these facilities remains a challenge. The transfer of neonates to LMICs for specialised care is fraught with numerous challenges, including inadequate transportation infrastructure and a shortage of qualified medical personnel for neonatal transfers. This often results in poor outcomes for critically ill newborns who require transfer to higher-level care facilities. A prospective study by Karmegaraj *et al.* (92) involving 138 neonates with congenital heart disease transported over a median distance of 138 km (5–425 km) to a paediatric cardiac programme in southern India reported that upon arrival, 42% had end-organ injury, 24% had metabolic insult, and 36% had a California Transport Risk Index of Physiologic Stability Score (Ca-TRIPS) >25. Ca-TRIPS was created and validated in 2001 by Lee *et al.* (93). It is a practical, physiologically based, empirically weighted method for evaluating neonatal transport outcomes by examining four components, namely, temperature, blood pressure, respiratory status, and reaction to noxious stimuli (93). A Ca-TRIPS score above 25 is significantly associated with mortality ($p = 0.005$), sepsis ($p = 0.035$), and prolonged ventilation ($p < 0.001$).

Sick newborns within the catchment areas of these specialised centres face risks of adverse outcomes due to limited access, which is partly caused by the absence of coordinated neonatal transport services and frequently unsafe transfer practices.

A study in Port Harcourt, Nigeria, aimed at evaluating neonatal transport services and the preparedness of healthcare workers in 28 selected health facilities (tertiary hospitals, private hospitals, and primary health centres) found that private cars and taxis were the most common modes of transport in 24 (85.7%) facilities. Two facilities (7.2%) had ambulances equipped with transport incubators. Nurses and nurse attendants without formal training in neonatal transport network services accompanied referred neonates in two (7.2%) facilities. The majority of referring facilities (78.6%) either rarely or never contacted receiving centres before the arrival of neonates, and most did not provide follow-up referrals after offering newborn care. There was no trained emergency transport team at any of the facilities (0%) in question (94).

Context-specific approaches informed by research into the unique challenges of newborn transport in the region are, therefore, an essential step towards establishing a safe and effective neonatal transport system.

2.5 Sub-Saharan Africa's unique position as a region within the LMICs

The Sahara Desert, historically a major hub for trans-Saharan trade, particularly in salt, gold, and slaves, began its downturn due to Atlantic shipping and the Moroccan invasion in 1591. It is currently viewed by many as the dividing line of the African continent. Geographically, any region south of the Sahara is classified as Sub-Saharan Africa. However, this geographical definition is distorted by policymakers such as the World Bank and the

International Monetary Fund, as well as academics who, for various reasons, including funding, culture, race, and ignorance, maintain their own lists of countries considered Sub-Saharan. Over the centuries, the region has been described by various terms, including "black Africa" and "tropical Africa", until, as recently as the 1980s, the term "Sub-Saharan Africa" gained prominence.

An example of the differing classifications is observed with Somalia and Djibouti. Both nations are located in the Horn of Africa, south of the Sahara Desert, yet the International Monetary Fund oversees them through its Middle East and Central Asia departments. Previously, the World Bank classified both countries as part of Sub-Saharan Africa; however, in 2000, it reclassified Djibouti as part of the Middle East and North Africa regions. Eritrea, located to the north of both Somalia and Djibouti, is considered a Sub-Saharan country. The World Bank includes the Arabic-speaking nations of Mauritania and Sudan within Sub-Saharan Africa, whereas the International Monetary Fund does not.

Sub-Saharan Africa (Figure 6) consists of 48 nations, of which 23 are classified as low-income, 18 as lower-middle-income, 6 as upper-middle-income, and 1 as high-income. The North African nations of Algeria, Egypt, Libya, Djibouti, Morocco, and Tunisia are excluded. In 2019, its population was 1.109 billion. The population is predicted to increase by 78.2% to 1.976 billion in 2043 due to high fertility rates (95).

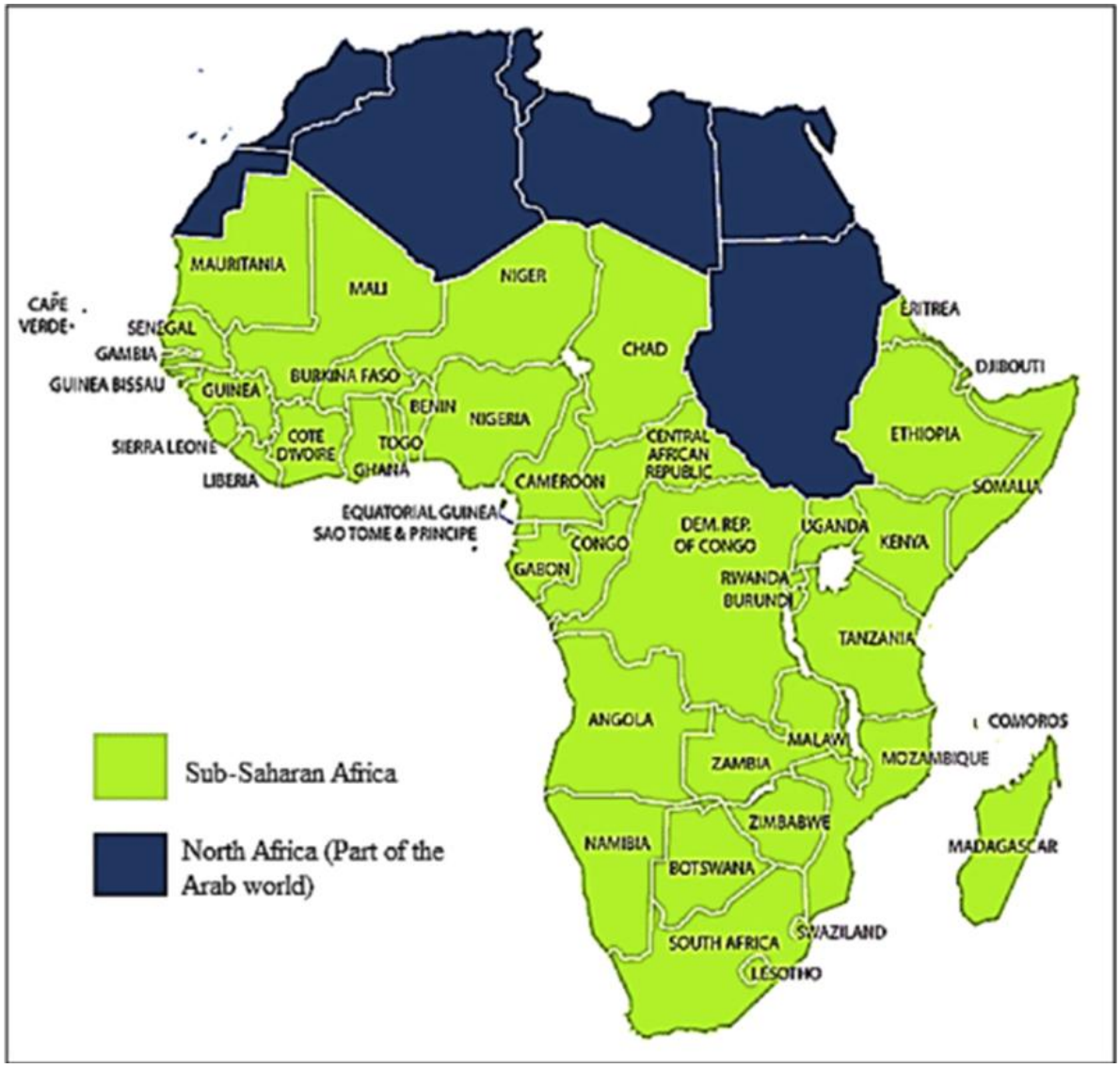

Figure 6: Location of Sub-Saharan Africa. Source: http://blogs.ft.com/materialworld/2014/05/11/part-lll-Sub-Saharan-Africa/ (Retrieved: 01.02.25)

The Sub-Saharan region exhibits varying economic and health indicators compared to other low- and middle-income regions. Recent World Bank data indicate that, although the global poverty rate has declined from 56% in 1990 to 40% in 2018, the number of impoverished countries continues to rise. In other words, 40% of the world's population currently lives below the US$1.90-a-day poverty line, with Sub-Saharan Africa accounting for 66% of the global extremely poor population (96). Compared to other regions, the poverty rate in Sub-

Saharan Africa has not declined sufficiently to keep pace with regional population growth. In 2018, an estimated 433 million Africans lived in extreme poverty, an increase from 284 million in 1990 (96).

What is even more concerning than the significant number of Sub-Saharan Africans experiencing severe poverty in 2018 is the limited advancement achieved in poverty alleviation over the past 30 years. The East Asia and Pacific region, along with recent developments in South Asia, has shown a remarkable decrease in poverty levels during this period, despite starting from comparable baselines only a generation prior.

Africa's diversity, particularly in the Sub-Saharan region, revolves around culture, religion, ethnicity, and, crucially, socioeconomic status. While the region may have made limited progress in reducing poverty, some economies still have poverty rates above the world average. This heterogeneity not only increases the likelihood of exposure to the threats of conflict and climate change but also presents unique challenges to healthcare planning and, consequently, requires a different approach compared to other LMICs.

2.6 Ghana: A Sub-Saharan African country with changing socioeconomic dynamics

Ghana (Figure 7) has a population of 30.8 million as of 2021, according to the Ghana Population and Housing Census 2020 (97). It comprises 16 administrative regions, with Accra serving as both the national capital and the seat of the Greater Accra Region.

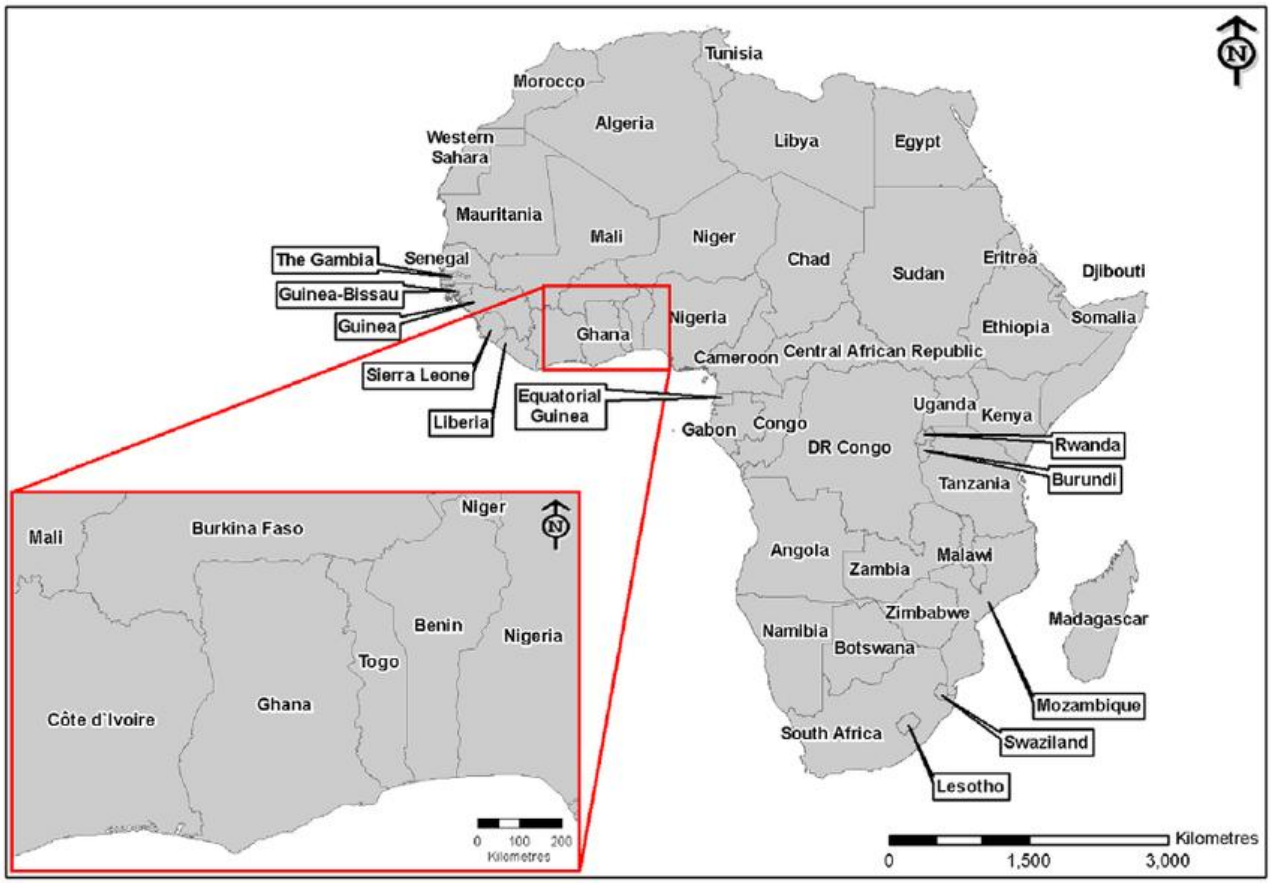

Figure 7: Map of Africa showing the location of Ghana.
doi:10.1371/journal.pntd.0001001.g001

It shares borders with Burkina Faso to the north, the Gulf of Guinea to the south, Togo to the east, and Côte d'Ivoire to the west. More than half (56.7%) of the population resides in urban areas (97). A significant portion of Ghana's population, specifically 58.1%, falls within the age range of 15–59 years. Additionally, 35.4% of the population is comprised of individuals aged 0–14 years, while 6.5% are aged 60 years and older (97).

In recent decades, Ghana has experienced an economic transformation that marked its transition from a lower-income to a middle-income country in 2012. This transformation has profoundly impacted the changing social landscape and population demographics. Notwithstanding the increase in urban populations, the under-5 mortality and child

mortality rates are significantly higher in rural areas compared to their urban counterparts, with 75 deaths per 1000 live births occurring in rural regions, in contrast to 64 deaths per 1000 live births in urban settings (97). In Ghana, annual neonatal mortality rates have gradually decreased over the past decade, from 29 per 1000 live births in 2014 to 24 per 1000 live births in 2018, and to 17 per 1000 live births in 2022 (11). Although national figures fluctuate, a significant proportion of under-five mortality is attributable to neonatal deaths. Major burdens are often observed in the Greater Accra, Ashanti, and Northern regions, accompanied by notable rural–urban disparities. Data indicate that the Central Region has experienced reductions in neonatal mortality rates. According to a ten-year assessment of early childhood deaths, the Central Region recorded a NMR of 14 per 1,000 live births, compared to 23 per 1,000 live births in the Ashanti Region and 32 per 1,000 live births in the Savannah Region in the north (11). Preterm births are very common in the country. In 2010, Ghana's preterm birth rate was around 14.5% of all live births (98), compared with the global figure of 11.1% (47). The national rate was higher than the 12.3% rate for Sub-Saharan Africa (47) and far larger than the 8.2% rate reported for 22 LMICs (99). The rate was reduced marginally to 12 per 1000 live births in 2019 (100).

Over the past two decades, Ghana has made significant progress in maternal and child health outcomes and has outperformed its peers in the subregion. Nationally, the under-5 mortality rate declined from 111 to 52 deaths per 1000 live births between 2003 and 2017. Although the nation narrowly missed achieving the MDG 4 target, which aimed to reduce under-5 mortality by two-thirds between 1990 and 2015 (101), the progress still reflects an overall reduction of 53 %. Ghana's under-5 mortality rate is below the LMIC 2017 average of 54.1 deaths per 1,000 live births, compared with its peer countries. If current efforts can be

accelerated and sustained, the country is projected to achieve SDG targets for infant and neonatal mortality by 2030 (Figure 8).

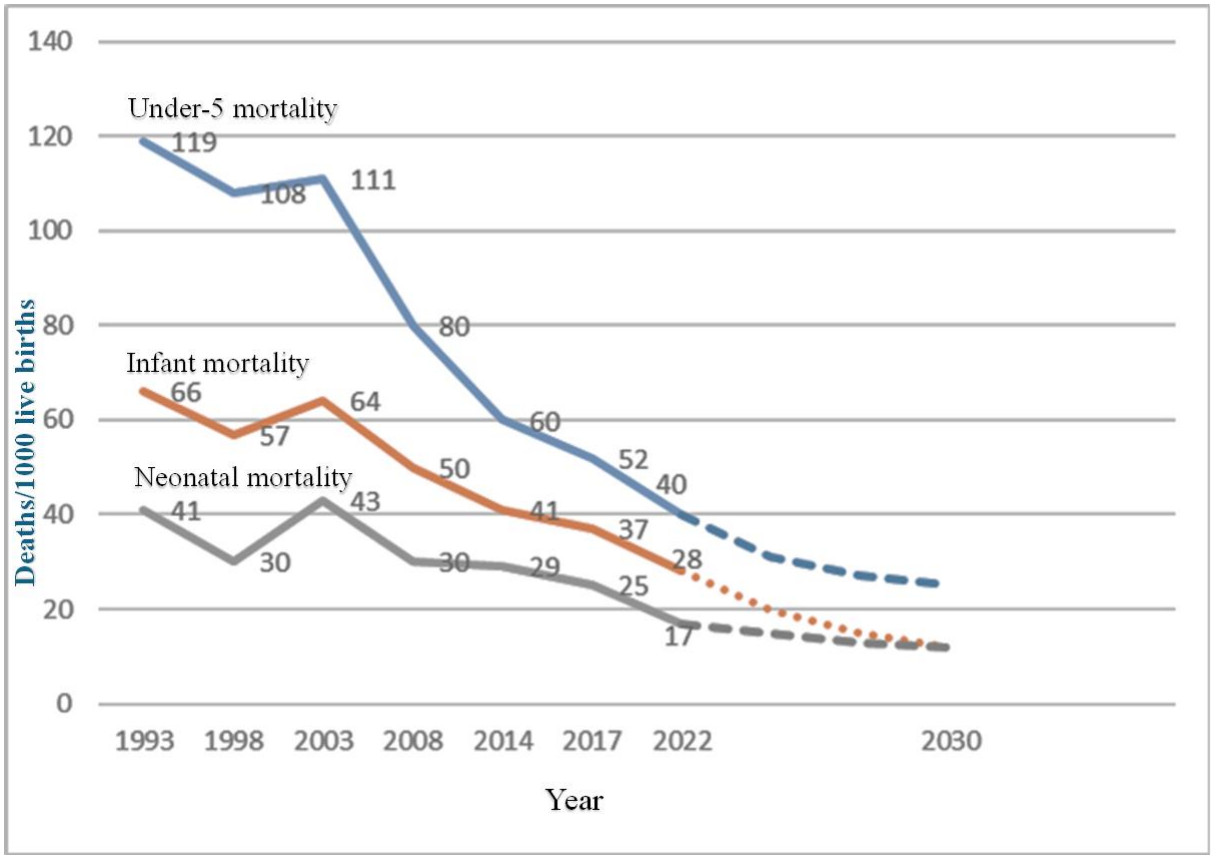

Figure 8: Trends and projections: Ghana's child mortality rates, 1993–2030. Agyekum *et al.* (102). Public health expenditure for Universal Health Coverage in Ghana. World Bank; 2024 Mar 4 Source: World Bank staff, based on Ghana Demographic Health Survey, 1988–2022, and Ghana maternal health survey 2017 (GSS, GHS, and ICF 2018).

2.6.1 Healthcare delivery/organisation in Ghana

Ghana has a three-tier, plural, and decentralised healthcare system divided into tertiary, secondary, and primary levels of care, comprising a mix of public and private providers (Figure 9). The health sector, which includes the public, private, faith-based, and traditional medicine sectors, is overseen by the Ministry of Health. Tertiary care facilities in the public sector are autonomous agencies, while community, primary, and secondary care facilities

are part of the Ghana Health Service, a Ministry of Health agency. The private, faith-based, and traditional medicine sectors are legally regulated and associated (102).

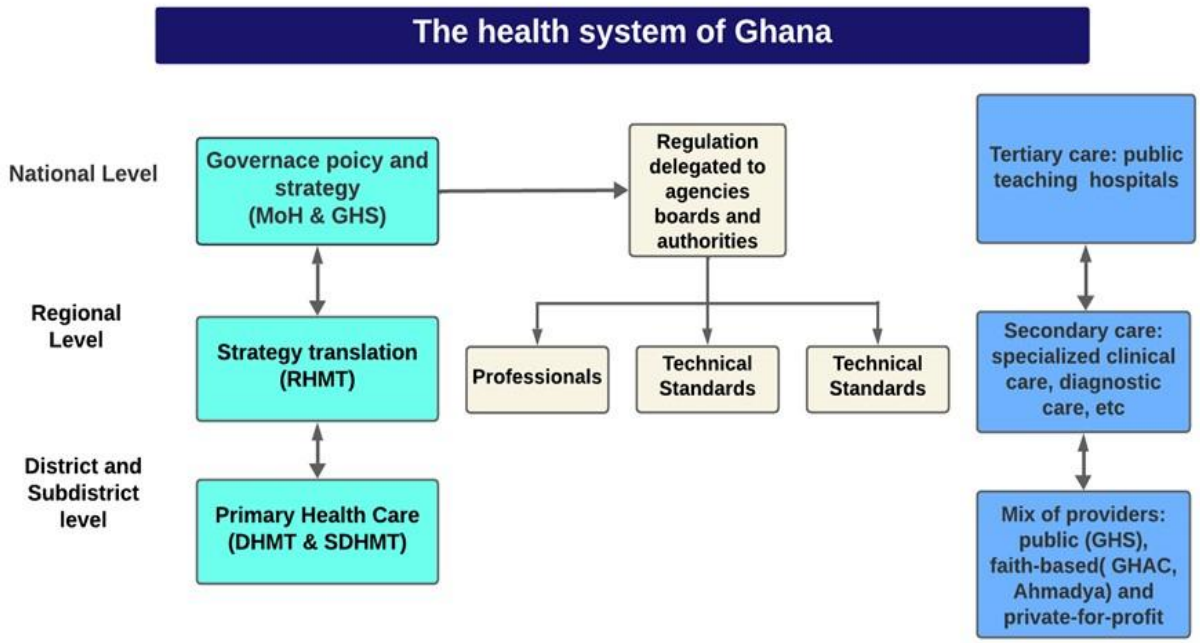

Figure 9: Ghana's health system organisational structure: Agyekum *et al.* Public health expenditure for Universal Health Coverage in Ghana. World Bank; 2024 Mar 4, Page 12. Notes: MOH = Ministry of Health; RHMT = Regional health management team; PHC = Primary healthcare; DHMT = District health management team; SDHMT = Subdistrict health management team; CHAG = Christian Health Association of Ghana; GHS = Ghana Health Service

The country has committed to achieving universal health coverage, ensuring that everyone has access to the healthcare they need without facing financial hardship. The operational definition of UHC provided by the Ghana Ministry of Health emphasises equitable, timely access to high-quality healthcare for all citizens, irrespective of their capacity to pay during service utilisation (103). The Ministry of Health seeks to lower patient and population barriers to healthcare and expand access to high-quality essential healthcare, with a focus on primary and specialised healthcare service delivery (104). These medical services are provided by the Ministry of Health's hospitals, clinics, health centres, community-based

health planning and services (CHPS), as well as private clinics and hospitals. The Ministry of Health's public health and preventive care programmes help reduce barriers to care for patients and the population (104).

Enhancing access to healthcare, regardless of financial capacity at the time of usage, is a vital national priority. Ghana implemented a social health insurance programme in 2003 to replace its "cash and carry" out-of-pocket system, making it the first nationwide programme of its kind in Sub-Saharan Africa. The purpose of the National Health Insurance Scheme is to lower the cost of medical care (105). The programme run by the National Health Insurance Agency has made strides, but many obstacles remain.

About 95% of the nation's ailments are covered by the NHIS benefits package, which aims to increase access to healthcare for all. The NHIS is available to all Ghanaian citizens, and the scheme provides premium and yearly exemptions to vulnerable groups, including children (under age 18), the elderly (70 years and above), indigents, persons with disabilities, pregnant women, and beneficiaries of the Livelihood Empowerment Against Poverty programme (106). The NHIS defines indigents as people who a) have no recognised source of income, b) are unemployed, and c) have no recognised place of abode (107,108). Despite these exemptions, many people have either never registered or have failed to renew their NHIS membership and continue to pay out of pocket to access health services (109,110). Family and social support (111,112) and personal income through donations (113) have been the primary sources of healthcare financing for many poor and vulnerable people in Ghana who cannot afford NHIS subscriptions (113). As of 2024, individuals aged 70 and over, as well as children under 18, must pay GH¢8.00 (US$1.33) for the first processing fee and GH¢5.00 (US$0.83) for each renewal. A one-time premium of GH¢30.00 ($4.99) and a

yearly renewal premium of GH¢27.00 (US$4.49) are required for those who are not eligible for the exemption (114). Even though the NHIS aims to guarantee everyone's access to healthcare, in 2017, it was estimated that 35% of the population were members (115), and as of 2021, about 68.8% of the population was covered by health insurance, with the remaining 31.2% not covered (116). The challenge has been to strike a balance between expanding coverage and preserving sustainability.

Geographical access presents a significant barrier to healthcare in Ghana, with excessive child mortality closely linked to the inaccessibility of services. More than two-thirds (70%) of the population lives in communities located more than 5 kilometres away from the nearest health facility (117). Childhood mortality in such communities is 40% greater than in communities less than 5 kilometres from health facilities (117). There is a significant discrepancy in the health status of urban and rural areas. As Ghana entered the 21st century, infant mortality rates in rural areas were 60% greater than rates in urban areas (117).

The country has a national ambulance service that provides pre-hospital emergency medical care and transport. As of 2020, the country, with 275 constituencies and 8,847 healthcare facilities, has 362 functioning ambulances and 180 ambulance service stations (118). Despite sustained growth in ambulance services over the years, coverage has remained low, even in the capital, Accra, where the ambulance-to-population ratio is approximately 1:250,000—a ratio 5 to 10 times below expert-recommended ratios for lower-income countries (9,119). Public utilisation also remains low, with the current norm for transporting the injured or ill to the hospital being private vehicles and taxis, due to the belief that taxis are faster than ambulances (9). Ghana has no dedicated neonatal ambulance transport service. The referral

systems of women with high-risk pregnancies from rural areas to a facility with a neonatal intensive care unit (NICU) constitute a significant challenge in the country. One-third of pregnant women (34%) in Ghana live beyond the clinically relevant two-hour distance from facilities expected to provide life-saving obstetric care, impacting timely access to appropriate care during obstetric emergencies (120). The country has implemented several initiatives designed to facilitate access to the appropriate level of care. This involves a tiered approach to care delivery across primary, secondary, and tertiary levels, building the capacity of facilities to manage emergency complications, and implementing referral policies and guidelines (121). A recent study, however, has demonstrated that the emergency obstetric referral system linking a typical teaching hospital in an urban district of Accra, Ghana, with peripheral referral facilities is functioning far below its expected potential (121).

Despite Ghana's high maternal and neonatal morbidity and mortality rates, along with a substantial preterm birth rate, the impact of enhanced referral systems connecting lower-level health centres to tertiary neonatal units has not been thoroughly studied or well documented.

2.7 Kangaroo Mother Care (KMC)

KMC is a method in which the infant is carried in a skin-to-skin position with the mother (Figure 10). The concept was developed in 1978 by Colombian paediatrician Edgar Rey, who introduced KMC to address the shortage of incubators and the detrimental effects of separating mothers from their newborns in neonatal care units (122). It was explicitly designed for preterm and low birth weight infants, and has demonstrated numerous benefits, such as strengthening the mother–baby bond, promoting breastfeeding,

preventing hypothermia, and facilitating early discharge from the hospital (123–125). Numerous studies over the years have identified KMC as a cost-effective intervention with the potential to reduce neonatal morbidity and mortality.

Figure 10: Kangaroo Mother Care position: how to hold the infant in KMC. Source: Jadhao *et al.*(126)

A Cochrane review of randomised-controlled trials comparing KMC with conventional neonatal care or early-onset KMC versus late-onset KMC in LBW infants reported that KMC was associated with a statistically significant reduction in the risk of mortality, nosocomial infection/sepsis, and hypothermia (24). Although the use of KMC in LBW infants as an alternative to conventional neonatal care, especially in resource-limited settings, is supported by evidence from this review, there is insufficient information to recommend the effectiveness and safety of early-onset continuous KMC in unstable or relatively stabilised LBW infants. Therefore, the previous WHO recommendation was to use KMC early, as soon

as neonates are clinically stable. A more recent review of 21 trials and meta-analyses (124 studies) on KMC use in neonates weighing less than 2,000 g reported a significant reduction in hypothermia, hypoglycaemia, mortality, and length of stay in hospital compared to neonates receiving conventional care (24).

A study at Jinja Hospital in Uganda assessed the feasibility of KMC use in unstable neonates weighing ≤2,000 g but recommended conducting more randomised-controlled trials in resource-constrained settings (127). Worku and Kassie (2005) conducted a study in Addis Ababa to assess the effectiveness of early KMC before stabilising low birth weight infants, comparing it with traditional care methods. They found that the early KMC group had improved survival rates for preterm and low birth weight infants within the first 12 hours and beyond, when compared to those receiving conventional care (128). Unfortunately, most published literature on KMC trials has emerged from developed countries, focusing on stable newborns.

Since its inception, the KMC intervention has halved the deaths of preterm and low birth weight infants in low- and middle-income countries due to its numerous advantages (129–131). Following recommendations from previous studies, the WHO Immediate KMC Study Group conducted a study on the safety and efficacy of KMC initiated soon after birth among infants with low birth weight (132). It was a multi-centre, randomised-controlled trial conducted in five hospitals across Ghana, India, Malawi, Nigeria, and Tanzania, involving 3,211 infants and their mothers with a birth weight between 1.0 and 1.799 kg. The infants were assigned to either immediate KMC (intervention group, 1,609 infants) or conventional care in an incubator or a radiant warmer until their condition improved, followed by KMC (control group, 1,602 infants). The primary outcomes were death during the neonatal period

(the first 28 days of life) and death in the first 72 hours of life. Death during the first 28 days occurred in 191 infants in the intervention group (12.0%) and in 249 infants in the control group (15.7%) (relative risk of death, 0.75; 95% CI, 0.64 to 0.89; P=0.001); death during the first 72 hours of life occurred in 74 infants in the intervention group (4.6%) and in 92 infants in the control group (5.8%) (relative risk of death, 0.77; 95% CI, 0.58 to 1.04; P=0.09). The trial was halted early at the recommendation of the data and safety monitoring board due to reduced mortality among infants receiving immediate KMC (132).

2.7.1 Policy and public health initiatives

The WHO has recognised prematurity as the leading cause of death for children under 5, with an estimated 15 million babies born preterm each year (27). KMC has emerged as a life-saving intervention for preterm and LBW babies. Following the most recent study on KMC (132), the WHO has launched new guidelines to improve maternal and newborn health outcomes through infant- and family-centred developmental care, highlighting KMC as an essential standard of care for all babies born early or small, starting immediately after birth (27,133). To promote the widespread adoption of KMC, the WHO has developed a global position paper and an implementation strategy to facilitate easy scale-up and adaptation across countries. These resources aim to integrate KMC into national and international health programmes, promote political commitment, and secure dedicated support budgets (27). This strategy emphasises the need for policy changes that encourage the adoption of KMC in both healthcare facilities and home settings (133). The implementation strategy targets a broad audience, including policymakers, programme managers, governmental and non-governmental organisations, and healthcare providers at all levels. It provides guidance on implementing KMC as the foundation of care for preterm or LBW infants, tailored to specific health systems and cultural contexts (133). The strategy also seeks to galvanise the

international maternal, newborn, and child health community to support KMC in improving the health and well-being of these infants and their families. Achieving a successful scale-up of KMC requires integrating it into existing maternal and newborn care frameworks, fostering advocacy and partnerships, and ensuring that parents and families play a central role in caring for their infants. This humanises healthcare by keeping mothers and infants together from birth and supporting their continuous care (133).

2.7.2 Kangaroo Mother Care during neonatal transport

The use of KMC and other alternative methods for maintaining thermal stability during neonatal transport has not yet been well studied in resource-constrained settings; this has been identified as one of the areas proposed for future research in a published systematic review of neonatal transport (83). Results from such studies would be crucial in shaping technical guidelines for healthcare professionals, facilities, and organisations tasked with establishing health system priorities and policies concerning the transport of neonates in LMICs.

Neonatal transport is not without risk. High levels of stress characterise the initial postnatal period, and the transition post-delivery is accomplished within the first 4 to 6 hours after delivery, though it can take up to 12 hours. The transportation of neonates from the delivery room to neonatal units also adds stress.

Transporting low birth weight infants shortly after delivery is associated with an increased risk of intraventricular haemorrhages, partly due to repeated vibrations to the head and the harmful effects of fluctuating blood pressure and temperature instability (134). Incubator

transport has the disadvantage of separation of mother and infant, and an increased risk of mortality in the event of an accident if not secured well (29).

Additionally, neonatal ambulance transfers are often associated with worse outcomes in settings with limited resources and undertrained ambulance personnel. This lack of training hinders personnel's ability to ensure safe and efficient transportation, resulting in increased morbidity and mortality in newborns (135). These difficulties are exacerbated because many resource-poor communities lack the necessary equipment for newborn transport, such as incubators, ventilators, and monitoring devices (136). Over the years, KMC has been proven effective not only for thermal control and breastfeeding but also for bonding between mother and infant. Such benefits are observed across various settings, weights, gestational ages, and clinical conditions (137). The evolution of KMC for neonatal transport emerged as a practical solution in regions with limited access to high-quality neonatal care. This adaptation has been built upon the need to address neonatal mortality rates, which are high in areas such as Sub-Saharan Africa, where transport services for newborns are limited, and those who need to travel often do so under less-than-ideal conditions (83,138).

KMC development and research demonstrate its potential as a low-cost, effective intervention for neonatal care and transport, especially in low-resource settings. As it stands, there is a continued need for large-scale randomised trials to spur efforts to collect additional evidence to inform policy and scale up efforts for the intervention (83).

Postnatal transportation employing KMC has some similarities to safe in-utero transfer. It offers numerous advantages, including maintenance of cardiorespiratory stability, thermal control, reduced oxygen and energy expenditure, and improved mother–baby bonding. Its

appropriateness for use in the transport of critically ill neonates who require repeated handling and interventions during transport has not been studied due to ethical concerns (131,139). The few studies on KMC use for transport, conducted primarily in resource-rich settings and with stable neonates, have reported significant and sustained stability in heart rate, respiratory rate, oxygen saturation, and temperature during transports lasting from 10 to 300 minutes, with parents feeling reassured, comfortable, and safe (29,139).

2.7.3 Implementation challenges

Neonatal transport is a critical component of neonatal care, and implementing KMC presents challenges for healthcare providers. One significant difficulty is ensuring continuous skin-to-skin contact between the caregiver and the baby, which is one of the core elements of KMC (140). Maintaining this contact during transportation is often challenging due to movement, the presence of medical devices, and varying transportation conditions. Moreover, exclusively breastfeeding or using breast milk during transport requires careful planning and the availability of suitable feeding mechanisms (140). Transport vehicles should be equipped for KMC, providing a safe and secure environment for skin-to-skin contact. Medical emergency protocols must also be developed and implemented, including training healthcare personnel on KMC and neonatal transport procedures to manage any medical emergencies that may arise during transport (140).

Tailor-made strategies and interventions are essential for effectively tackling these challenges. This involves qualitative studies to explore contextual appropriateness, specialised training for healthcare providers to integrate KMC principles with neonatal transport protocols, ensuring that transport vehicles are properly equipped, and developing context-appropriate discharge and follow-up plans for infants and their families.

2.7.4 Impact of cultural beliefs

Cultural beliefs and practices significantly influence the acceptance and implementation of KMC in various communities (141). In low- and middle-income countries, where KMC has been widely adopted to mitigate adverse outcomes for LBW infants, cultural perceptions play a crucial role in its utilisation by parents. Traditional beliefs about infant care, body contact, and the roles of mothers and fathers can either facilitate or hinder the practice of KMC. Policymakers and healthcare providers must thoroughly understand these cultural factors to support and promote KMC practices, including KMC transport. Tailoring interventions to align with cultural values and educating communities about the benefits of KMC can enhance its acceptance and implementation, ultimately reducing neonatal and child mortality rates in LMICs. In a scoping review of 22 studies to assess facilitating factors and barriers to Kangaroo Mother Care utilisation in low- and middle-income countries, the availability of skilled health workers, caregivers' knowledge of KMC, a positive mother–nurse relationship, feeling comfortable and safe with an infant in the KMC position, use of KMC educational/promotional materials such as KMC pictures or dolls, pictorial presentations and photographs/posters of mothers practising KMC, and family support during KMC practice were facilitators of KMC acceptability (142). However, some cultural practices and beliefs were barriers to the acceptance of KMC. In some Bangladeshi, Ethiopian, Indian, and Ghanaian societies, KMC practice was not culturally acceptable, as holding the infant in the front was traditionally taboo. Additionally, some mothers believed that excessive infant holding fostered dependency in their babies, which could distract them from typical household tasks. Most notably, there was a belief that a 'malnourished' baby (LBW) should be fed rather than kept in the KMC position (142). Therefore, understanding the local cultural context is essential for successfully implementing KMC programmes.

For KMC to be successfully incorporated into routine medical practice, facility management, leadership support, and highly qualified medical personnel are essential. Additionally, parents of preterm newborns and other family members should be educated and encouraged to practise KMC (143). KMC is a multifaceted, behaviour-driven intervention. Stakeholder and user participation levels are necessary for implementation success (144). By tackling barriers and fostering trust, and by effectively integrating and expanding KMC transport within the healthcare system, we can enhance neonatal survival alongside other initiatives already in place.

2.8 Summary

The background literature indicates that preterm and low birth weight infants receiving KMC can maintain their body temperature at clinically acceptable levels and experience fewer incidents of hypothermia and hyperthermia compared to those receiving conventional care. KMC also provides several physiological advantages, such as increased and exclusive breastfeeding duration. Previous research has demonstrated that KMC is more economical than conventional approaches, rendering it a feasible alternative in developing nations. However, its application in transportation has not been thoroughly investigated, with only a limited number of studies conducted in developed countries and a single study in an LMIC, specifically the Philippines. Effective implementation of this intervention requires specialised training for health professionals and education for mothers.

There is a clear need for well-designed RCTs and/or observational studies with large sample sizes of low birth weight and preterm infants, particularly in SSA, where neonatal mortality is unacceptably high and KMC transport could be a cost-effective and viable option.

Additionally, further qualitative research is necessary to understand the acceptability of KMC transport among mothers in the subregion, particularly across different cultural contexts, and to identify potential barriers to uptake that may affect the effective implementation of KMC transport programmes. The inability to identify research conducted within the subregion raises concerns about acceptability and whether substantial variations exist between settings. There is a lack of high-quality systematic evidence regarding neonatal transport practices in SSA. In Sub-Saharan Africa, particularly in Ghana, KMC transport has never been evaluated. Cultural and community practices may influence the acceptability and practicality of this low-resource intervention. This study represents the first investigation in a Sub-Saharan country, with potential implications for a region experiencing the highest neonatal mortality rates.

In the next chapter, a systematic review of neonatal transport in the subregion is presented, along with an analysis of cost-effective treatments utilised during transport, to begin addressing this gap in the research literature.

Chapter 3: Systematic literature review

3.1 Introduction

This chapter presents Article A, a systematic review of neonatal transport in Sub-Saharan Africa, a summary of its context, and a full published version of the review. The chapter then concludes with a synopsis of the key points, the measurable impact of the work, and a discussion of its contribution to the thesis. As discussed in chapter 2, there is clear evidence that poorly structured transport systems in developing countries are a major contributor to increased neonatal mortality rates. The only previous systematic review of neonatal transport in developing countries (83) provided evidence on neonatal transport across the developing world to highlight key conclusions and knowledge gaps, guiding the development of clinical guidelines and practical tools to support safe neonatal transport. This review aims to update previous work and focus specifically on transport in Sub-Saharan Africa, which has the worst global economic and health statistics. It further seeks to provide evidence of the use of cost-effective interventions employed in the transport process in the subregion. It addresses the first of the research objectives as outlined in chapter 1:

> **Establish what is known in the current research literature regarding neonatal transport practices in Sub-Saharan Africa.**

3.2 Published article: Article A

The published article is entitled "Neonatal transport practices and effectiveness of the use of low-cost interventions on outcomes of transported neonates in Sub-Saharan Africa: A systematic review and narrative synthesis." It is reproduced in full on the following pages in its published form (145). The protocol for this review was registered in the PROSPERO database and is available in Appendix B. The supplementary data associated with this article,

including the search terms and Mixed Methods Appraisal Tool (MMAT) scoring, are provided in Appendix C.

3.3 Publication and impact

The systematic review was accepted for publication in *Health Science Reports* in February 2024. *Health Science Reports* is a well-regarded, open-access, peer-reviewed journal with a respectable impact factor of 2.1. According to Google Scholar, the article has been cited 7 times since its publication online (as of 26 May 2025).

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STUDY PROTOCOLS

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Neonatal transport practices and effectiveness of the use of low-cost interventions on outcomes of transported neonates in Sub-Saharan Africa: A systematic review and narrative synthesis

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Abstract

Background and Aims: Neonatal deaths contribute significantly to under-5 mortality worldwide with Sub-Saharan Africa (SSA) alone accounting for 43% of global newborn deaths. Significant challenges in the region's health systems evidenced by huge disparities in health facility deliveries and poor planning for preterm births are major contributors to the high neonatal mortality. Many neonates in the region are delivered in suboptimal conditions and require transportation to facilities equipped for specialized care. This review describes neonatal transport across the subregion, focusing on low-cost interventions employed.

Methods: We conducted a systematic review of studies on neonatal transport in SSA followed by a narrative synthesis. A search in the databases CINAHL, EMBASE, MEDLINE, Web of Science, African Index Medicus, and Google Scholar was performed from inception to March 2023. Two authors reviewed the full texts of relevant studies to determine eligibility for inclusion which was subsequently cross-checked by a third reviewer using a random 30% overlay. The quality of the included studies was assessed using the Mixed Methods Appraisal Tool.

Results: A total of 20 studies were included in this review involving 11,895 neonates from 10 countries. All studies evaluated the transfer of neonates into referral centers from the peripheries. Most neonates were transferred by public transport ($n = 12$), mostly in the arms of caregivers with little communication between referring facilities. Studies reporting on ambulance transfers reported pervasive inadequacies in both human resources and transport equipment. No study reported on the use of Kangaroo mother care (KMC) in the transfer process.

Conclusions: The neonatal transport system across the SSA region is poorly planned, poorly resourced, and executed with little communication between facilities. Using cost-effective measures like KMC and improved training of community health workers may be key to improving the outcomes of transported neonates.

KEYWORDS
Kangaroo mother care, low-cost interventions, neonates, Sub-Saharan Africa, transport

Study question: What is the evidence on neonatal transport in Sub-Saharan Africa? What low-cost interventions are employed in neonatal transport in Sub-Saharan Africa to improve morbidity and mortality in transported neonates?

What's already known: A poorly structured transport process in developing countries is a major contributor to increased neonatal mortality rates. WHO recommended low-cost interventions including Kangaroo mother care improve outcomes in neonates stabilized within neonatal units in developing countries. Differing interventions to improve thermal and physiologic stability have been studied in other world regions.

What this study adds: As the only systematic review on neonatal transport practices in Sub-Saharan Africa, this study provides context-specific current evidence on studies performed in a subregion that has significant disparities compared to other regions classified as developing or Low-middle income countries.

1 | BACKGROUND

Significant progress has been made in child survival since the institution of the Millennium Development Goals (MDGs), over 2 decades ago. However, despite increased facility delivery, which was a focus of the MDG, neonatal mortality in low and low–middle-income countries (LMIC) remains high.

Even though over 62 countries were able to achieve MDG 4, the target was missed globally with the under-5 mortality rate (U5MR) reducing by 53% over 25-year period (1990–2015) instead of the targeted 75%.[1]

Globally, U5MR fell from 90.6 deaths per 1000 live births in 1990 to 42.5 per 1000 live births in 2015,[1] significantly below the MDG target. In percentage terms, the decline in neonatal mortality has been slower than that of postneonatal under-5 mortality: reducing by 47% compared with 58% globally. As a result, the portion of neonatal deaths among overall under-5 deaths increased from 40% in 1990 to 45% in 2015,[2] with several regions' resource-limited settings exceeding a mortality rate of more than 50%.[3]

The Sustainable Development Goals (SDG), a follow-up from the MDGs has an aim for all countries to achieve a U5MR of 25 or fewer deaths per 1000 livebirths by 2030 (SDG target 3.2.1) and a neonatal mortality rate (NMR) of 12 or fewer deaths per 1000 livebirths by 2030.[4] About halfway into the SDG era, the global U5MR is estimated to have decreased by 59% to 37.7% deaths per 1000 live births in 2019 and NMR reduced by just over half from 36.6% in 1990 to 17.5% deaths per 1000 live births in 2019.[5] This translates into a drop in the total number of deaths from 5.0 million in 1990 to 2.4 million in 2019.[5]

Sub-Saharan Africa (SSA) is currently made up of 48 out of the 52 countries on the African continent and is geographically located south of the Sahara Desert,[6] with an estimated total population of approximately 1.18 billion.[7] It has differing statistics, economically and in health service delivery compared to other regions considered LMIC. Approximately, 40% of the world's population are extremely poor and live below the US $1.90-a-day poverty line. SSA accounts for 66% of the global extremely poor.[8]

SSA and Southern Asia alone accounted for 80% of the global neonatal deaths in 2019.[9] Two-thirds of these occurred on the first day of life and almost three-quarters within the first week. The challenge to survive encountered by the neonate, therefore, starts at the place of delivery, with a risk of death up to 20 times higher in SSA and Southern Asia compared to high-income countries.[5]

Many newborn deaths are a consequence of a lack of contact with the health system or a lack of transfer systems to access higher-level facilities.[10–12] Unfortunately, in SSA, sick newborns in need of transfer to established specialized neonatal centers remain at risk of adverse outcomes because of under-resourced peripheral delivery facilities, lack of coordinated neonatal transport service, and frequently unsafe transfer practices. Prompt attention to appropriate referral of sick newborns might therefore significantly contribute to a reduction in the high mortality occurring on the day of birth.[13]

Challenges in every sector of the health system in SSA and most LMICs regarding newborn care including the absence of well-established ambulance services lend themselves to the need to explore the possibility of employing cost-effective but evidence-based, life-saving procedures in the neonatal transfer process. The results from such an exercise would inform technical guidelines for use by healthcare professionals, facilities, and organizations responsible for setting health system priorities and policies surrounding the transport of neonates in LMICs. The use of Kangaroo mother care (KMC) and other alternative methods of thermal stability for neonatal transport is not well studied in SSA, yet this has been one of the areas proposed for future research in several published studies on neonatal transport.

KMC is a practical, effective, and safe substitute for conventional neonatal care in preterm and low birthweight (LBW) infants mainly in resource-limited countries. It involves strapping the baby upright to the mother's chest in skin-to-skin contact. World Health Organization defines KMC with four components: early, continuous, and prolonged skin-to-skin contact between the newborn and mother, exclusive breastfeeding, early discharge from the health facility, and close follow-up at home.[14] Previous studies have reported its benefits in reducing the risk of morbidity and mortality among LBW infants.[15] The skin-to-skin component alone has also been reported to be associated with improved breastfeeding, cardiorespiratory stability, and improved responses to procedural pain in randomized controlled studies.[16,17]

1.1 | Rationale

While a review of neonatal transport in developing countries has been undertaken,[11] the field is advancing necessitating an updated review. The use of KMC for the care of stable newborns within neonatal units in resource-limited settings has been reported but there is a dearth of information on its use in neonatal transport. This study aimed to systematically review the literature on neonatal transport in SSA to explore all components including the use of cost-effective procedures.

2 | METHODS

A systematic review was undertaken according to the prospectively developed review protocol which conformed to Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines.[18] The review is registered with PROSPERO (registration number CRD42022352401).

2.1 | Literature search

A systematic literature search was conducted from inception to March 2023 of the following databases: CINAHL, EMBASE, MEDLINE, Web of Science, African Index Medicus, and Google Scholar. A combination of subject headings and keyword searches about neonates, transport or transfer, transport interventions, and all Sub-Saharan African countries was used. These were tailored to each database. The full list of search terms is available in (Appendix S1).

There were no restrictions placed on the date or language of the publication. However, the studies included were restricted to only those from SSA. Bibliographies of retrieved articles were reviewed for additional articles which meet the inclusion criteria. All selected articles were imported into RefWorks, ProQuest reference manager, and independently assessed by reviewers using the inclusion/exclusion criteria.

2.2 | Inclusion criteria

All peer-reviewed publications on neonatal transport, describing transport modalities/processes and outcomes within SSA were assessed.

2.3 | Exclusion criteria

Case reports, protocols, editorials, commentaries, or studies on neonatal transport that were not published in SSA. For studies with uncertainty about meeting the inclusion criteria, or where relevant data could not be extracted from the study report, the authors were contacted via email for additional data or clarification. If this was not forthcoming the study was excluded. In the case of studies of mixed samples where only a proportion of the study population meets the inclusion criteria (e.g., only a proportion of the transported infants are neonates, or communication was partly about the maternal prelabour transfer), the study was included if relevant data could be extracted.

2.4 | Definitions

A neonate is defined as a newborn infant with a chronological age of 28 days or less without regard to the postmenstrual age at birth.

A caregiver is defined as the individual who accompanies the neonate during transport, as identified by the study, and could be a family member, such as a mother, father, aunt, grandmother, or friend.

Pretransport, intratransport, and posttransport interventions refer to all interventions instituted to improve the outcome of referred neonates. These include training in the communication of medical personnel, interfacility prereferral communication, interventions that aim to refine or upgrade already existing methods of transport, and the introduction of new methods or equipment for transport and methods to improve physiologic stability.

Facility type was categorized as either primary, secondary, or tertiary health centers as identified by each study. Primary health centers included public and private maternity units, health centers, and health facilities with in-patient care as defined by individual studies based on the country's health structure.

Healthcare providers include hospital/facility administrators, paramedics, and medically trained providers such as doctors, midwives, and nurses.

2.5 | Data extraction

Articles retrieved using the search strategy were initially screened by title and abstract against the inclusion criteria by E. O. and checked by H. S. and F. F. with any disagreement over potential article relevance resolved through discussion.

Eligible papers were read in full text independently by E. O. and F. F. for inclusion and E. O. extracted study characteristics and outcome data from the included studies using a predefined data extraction form (Excel spreadsheet) which was subsequently checked for accuracy by H. S. or F. F. Papers which met the inclusion criteria at the abstract stage, but where a full-text article could not be obtained even after contact with authors were included if enough data could be extracted from the abstract. Data extracted were summarized to include, authors, country of study, the study aims and objectives, research methods/design, participants, information on the transport/transfer process, main findings, quality appraisal score, and study limitations. Summary characteristics were kept broad due to the vast methodological differences within and between the studies. For qualitative studies, directly reported participant data (e.g., verbatim quotations or scores), and author interpretations were extracted and

analyzed separately in order not to distort the contextual basis required to understand barriers and enablers of an efficient neonatal transportation system for the region.

2.6 | Quality appraisal

All reviewers independently assessed the 20 full-text papers using the Mixed Methods Appraisal Tool (MMAT), Version 2018.[19] Articles were assessed using the criteria within the tool that was appropriate for the study design; quantitative (randomized; nonrandomized: descriptive), qualitative, or mixed-methods design. Any disagreements were discussed within the team. No studies were excluded based on their quality but commented on in the narrative synthesis.

2.7 | Data summary and synthesis

The heterogeneity among the included studies, even for studies with similar methodologies made it taxing for combining quantitative data using meta-analysis, or a meta-synthesis for qualitative data. The general framework and specific tools outlined in the Economic and Social Research Council Guidance on the Conduct of Narrative Synthesis in Systematic Reviews[20] were applied.

We, therefore, proceeded to combine studies by summarizing their descriptive statistics followed by a textual narrative synthesis as opposed to a thematic synthesis. A textual synthesis held more potential to describe the gaps in the literature and to make transparent the heterogeneity between the studies as well as make the context and study characteristics of each study clearer.

To minimize the inherent selection bias of facility-based surveys regarding their population sample as well as minimizing bias in synthesizing studies, we have attempted to describe all outcomes and findings regardless of their statistical significance.

3 | RESULTS

Figure 1 gives a PRISMA flow diagram of the study search and selection process.[18] Forty-seven publications were identified, and seven articles were identified through hand-searching the bibliographies of identified studies. Duplicates were removed leaving 47 papers that were screened against the inclusion/exclusion criteria by their titles and abstracts. A total of 22 studies were reviewed in full

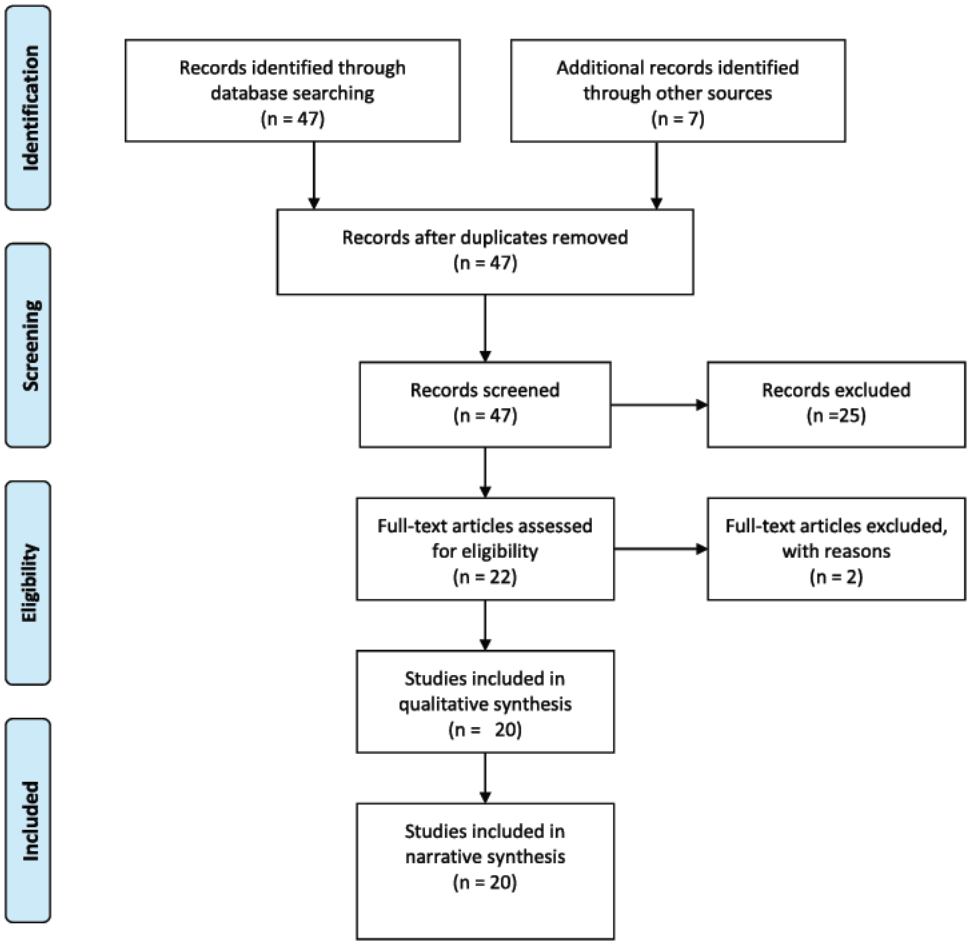

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-analysis flowchart.[23]

text. Out of these, two articles were excluded based on the exclusion criteria: The first is a registry-based study that focused on socio-demographic factors, pregnancy complications, and neonatal factors predicting admission to the neonatal unit without any distinction of outborn neonates[21] and the second study involved mother-baby pairs with data analysis mainly focussing on the mothers.[22] A total of 20 articles met our inclusion criteria and were included in the final review and analysis.

3.1 | Study characteristics

Table 1 provides a summary of study characteristics. Five studies (25%) were conducted in South Africa,[24–28] four (20%) were conducted in Nigeria,[12,29–31] two each (10%) were conducted in Ethiopia[32,33] Ghana,[34,35] and Senegal,[36,37] and one each (5%) from Cameroon,[38] Congo,[39] Guinea,[40] Mali,[41] and Uganda.[42] There were no randomized controlled studies. Two studies were qualitative[27,32] with the rest being descriptive cross-sectional studies: 11 retrospective and 7 prospective.

The focus of the studies was varied. Three studies were community-based surveys,[27,32,42] two studies evaluated the quality/effectiveness of a dedicated neonatal ambulance service,[24,25] one study evaluated barriers to an effective neonatal transport service,[32] one study evaluated the cost-effectiveness of a dedicated ambulance service[33] and the rest (13) were facility-based surveys.

The majority ($n = 18/20$) of the studies were published after 2000 with only two studies published between 1989 and 1994. Twelve of the studies was published after the last review of neonatal transport in developing countries.[11] All studies evaluated the transfer of neonates into referral centers from the peripheries.

The study populations were homogeneous in terms of age, as the ages of all the study participants enrolled were less than 1 month. The subgroup categories within studies however differed for example in gestational age, birthweight, and severity of illness as summarized in Table 1.

The included studies identified a total of 11,895 neonates who were either transferred into tertiary care from the peripheries or benefited from interhospital transport. Out of these, 848 neonates were included in two nonfacility-based studies which analyzed referrals by only community health workers into hospitals.

Although included studies had a varied focus, the majority focused on the description of the reasons for transfer and outcomes of neonates transported into the hospital ($n = 14$).[12,27,29–31,34–41,43]

3.2 | Quality assessment

The quality of studies using the MMAT assessment is shown in (Appendix S2). All studies met the MMAT screening criteria questions. The two qualitative studies were of good quality with clearly defined research questions, sampling methods, and clear links between data collected and inferences. The quantitative studies were of varied quality. Most studies addressed the research question well but a few studies either had unclear aims[38] or the stated aim was not addressed in the final analysis.[36]

Most quantitative studies described the target population well and used appropriate measurements. 15/20 studies were judged to have a sample that was representative of the target population, in 5/20 studies it was not possible to tell if the sample was representative. In sampling their participants, only one stated they used convenience sampling, however, a closer review of the studies suggested that most studies used convenience sampling. Most studies did not comment on any consideration about how study findings or the extent of missing data introduced biases. The discussion segments of some studies were limited and most studies often limited analyses to descriptive statistics on comparison groups and χ^2 or t tests to elucidate differences in outcomes.

3.3 | Synthesis of results

A neonatal transport service has several key components: Human resources, vehicles, and equipment, communication and family support, documentation and quality assurance, and feedback to referring units. Included studies varied greatly in their focus on the individual aspects of the transport service. These have been incorporated into four overarching themes including "mode of transport," "support during transport," "referral pathway and communication," and "neonatal care and access within health facilities."

3.4 | Mode of transport: Organized versus self-transport

As shown in Table 2, 16 studies either examined or commented on the mode of transport of neonates in the subregion. The mode of transport and neonatal outcomes were similar across studies regardless of study quality. Five studies examined regionalized/organized ambulance transport services using ground transport,[4,24,43] private ground ambulances,[33] fixed-wing helicopters, and ground ambulances.[28] Eight studies identified public transport as the main mode of transport with the majority (7/8) being transferred by taxis[12,34,35,37,38,40,41] and private vehicles.[30] In one study, a comment is made about 10% of the transfers being made by ambulance but the other modes of transfer are not analyzed.[36] Transfers on foot was the maximal mode of transport in three studies,[39,42] with one reporting as high as more than 30%.[40] Reported average distances for many transfers were <80 km but up to 200 km in helicopter transfers[28] (Table 2). The reported time of travel was however considerable ranging from 15 min to 48 h.[35,38,43] The reported average delay before admission to a referral center was 3.5 h with a maximum of 3 days.[37]

Support during transport: This is subdivided into (a) Use of equipment, KMC, or other low-cost interventions for transport and (b) human resources and family support:

TABLE 1 Study characteristics.

Study ID (year)	Country	Study design	Aims and objectives	Dates of data collection	Participant demographics	Level of transfer	Conclusion	Study limitations
1. Roux et al.[24] (1989)	South Africa	Descriptive Cross-sectional Quantitative Retrospective	Study of quality of interhospital transport of ill neonates by ambulances	May to June 1987	15 neonates 9 full terms, 6 preterms 10 neonates weighed < 1 kg	Interhospital transfer within the Witwatersrand province	Lack of equipment, especially in private ambulances increases risk. Staff development and control by a local national body recommended.	Small sample size Short study period
2. Njokanma and Fagbule[29] (1994)	Nigeria	Descriptive Cross-sectional Retrospective Quantitative	Review of the outcomes of neonates < 2.5 kg transferred for tertiary care	Retrospective March 1989 to December 1990 Prospective January to August 1991	103 neonates (59 male [M], 44 female [F]) 77.7% preterm 55.3% <1.5 kg 44.7% 1.5–2.5 kg	Transfers of outborn neonates (from home maternity units and primary centers) into a tertiary service	Resuscitation with emphasis on thermoregulation at delivery centers and adequate neonatal transport may improve outcomes in high-risk neonates.	No comparison was made to neonates delivered in the same unit who received similar care
3. Pieper et al.[28] (1994)	South Africa	Descriptive Cross-sectional Retrospective Quantitative	Description of the mode of transport and outcomes of transported neonates to NICU	January to September 1992	52 neonates, 29 M:23 F Gestational age 28–43 weeks	All neonates referred to a level 3 neonatal intensive care unit	High survival rate in transported infants, highest mortality in the asphyxia-related meconium aspiration syndrome and infants transported by ground ambulance.	No stated sampling methods The target population is not stated
4. Ndiaye et al.[36] (2003)	Senegal	Descriptive Cross-sectional Retrospective Quantitative	Description of factors associated with mortality of low-birth-weight neonates transferred into a tertiary Hospital	January 1998 to December 1999	180 LBW new-borns Mean weight 1452.5 ± 432 g	Community and peripheral centers into tertiary care	Prevention of LBW and improved collaboration between obstetricians and pediatricians is needed to improve the outcome of transferred neonates.	No comparison made with neonates of different weights better appreciate the associated factors
5. Enweronu-Laryea et al.[34] (2008)	Ghana	Descriptive Cross-sectional Retrospective Quantitative	Retrospective cohort comparing birth weight-specific survival and referral pattern of newborns requiring intensive	2007	Admissions into NICU during the study period (2078 before and 1815 after refurbishment)	Transfer from public and private health facilities to a tertiary center	Survival of referred newborns <2.5 kg improved from 56% (before) to 68% (after) Improvements in NICU facilities without	Lack of data on transport characteristics of transferred neonates resulting in hypothesized

TABLE 1 (Continued)

Study ID (year)	Country	Study design	Aims and objectives	Dates of data collection	Participant demographics	Level of transfer	Conclusion	Study limitations
			care before and after improvement of facilities.		out of which (178 vs. 287) were referred		attendant improvements in emergency obstetric services and neonatal referral systems are not enough to achieve the desired reduction in neonatal mortality.	exposure–effect relationship.
6. Dicko et al.[41] (2010)	Mali	Descriptive Cross-Sectional Retrospective	Description of problems associated with neonates transferred into a tertiary neonatal service	October 2006 to January 2007	760 referred newborns out of 1072 neonatal admissions. M: 57.7% F: 42.2% Preterm: 33.6% LBW: 43.6%	Transfer from community centers, maternity units and peripheral hospitals	91.6% of the cases were referred on the very day of their birth. Prematurity, perinatal anoxia respiratory distress were the main reasons for transfer Maternal illiteracy, LBW, and outborn birth were factors related to neonatal mortality.	Difficult to determine how representative the sample size was. The definition of hypothermia is not standard
7. De Vries et al.[25] (2011)	South Africa	Descriptive Cross-Sectional Retrospective	A retrospective evaluation of the impact of a dedicated obstetric and neonatal transport service on transport times within an urban setting	January to December 2005 and January to December 2008	All ambulance calls were coded for flying squad service during the period of study. 3257 flying squad calls out of a total of 46,074 in 2005 and 4865 flying squad calls out of a total of 65,885 in 2008	State-run ambulance service providing essential prehospital emergency care to the population of the Western Cape of South Africa	Significant improvement between 2005 and 2008 in all incidents evaluated. Performance improved from 11.7% to 46.6% of all incidents dispatched within 4 min. The program resulted in a reduction in total prehospital time from 177 to 128 min.	1. Absence of patient outcome measures Teams may have executed transfers more efficiently, but the appropriateness of the dispatch or the quality of the clinical management cannot be determined. 2. Potential investigator bias
8. Nalwadda et al.[42] (2013)	Uganda	Descriptive Cross-sectional	Assessment of the timely compliance (within 24 h) with	September 2009 and August 2011	724 newborns were referred by CHWs of whom 700 were	Community to hospital referrals	The newborn being sick, being born to a younger mother and a	

(Continues)

TABLE 1 (Continued)

Study ID (year)	Country	Study design	Aims and objectives	Dates of data collection	Participant demographics	Level of transfer	Conclusion	Study limitations
		Retrospective	newborn referrals made by community health workers (CHWs), and its determinants		successfully traced. 51% males, 49% female. 56% were delivered at a health facility. The mean age of mothers is 27 years, 93% married		reminder visit by the CHW to a referred newborn were strong predictors of newborn referral compliance.	
9. Nsibande et al.[27] (2013)	South Africa	Qualitative Cross-sectional study, Interviews were conducted using a structured questionnaire	Substudy to assess the effectiveness of the CHW referral system (in a bigger community randomized trial) by describing CHW referral completion rates as well as mothers' healthcare-seeking practices	June 2008 to June 2010	148 Referred sick Neonates. The mean age of mothers −24 years. Most had attended some high school; the majority were single and unemployed. 39% of mothers were HIV positive, 56% negative, and 5 (4%) had missing status.	Community to hospital	High compliance (95%) with CHW referral of sick babies in an urban setting. This suggests that CHWs can play a significant role, within community outreach teams, to improve newborn health and reduce child mortality.	
10. Katamea et al.[39] (2014)	Congo	Descriptive cross-sectional prospective	To study the frequency of extrahospital neonatal transfer to the neonatology unit and identify the risk factors associated with mortality.	January 2012 to December 2012	All neonates less than 7 days transferred and cared for until discharge. 150 transferred neonates out of 1412 admissions 12.9% F: 58, M: 92 LBW 64%	Maternity units and other health centers to a tertiary facility	Mortality was significantly related to maternal profession (saleswoman or worker), high level of education, gestational age <37 weeks dystocia vaginal delivery, male sex, birth weight <1.5 kg, and prematurity	Selection of cases discussed but no mention of criteria which led to the exclusion of 33 out of the 183 factors
11. Nlend et al.[38] (2016)	Cameroon	Descriptive, Cross-Sectional Prospective	To describe the transport modalities (means of transport, the reason for transfer, transfer delay, number of detours, the	October 2014 to January 2015	73 newborns referred during the study period. 1/73 was born outside the city and 72 were born in Yaoundé, (22%) were born	33% from the tertiary level or equivalent 20% from a lower-level structure such as a district hospital & 47% from a	Transfers of sick newborns are associated with poor prognosis because of an erratic itinerary, with an increased risk	Small sample size Lack of use of methods of accessing metabolic stability for long journeys

TABLE 1 (Continued)

Study ID (year)	Country	Study design	Aims and objectives	Dates of data collection	Participant demographics	Level of transfer	Conclusion	Study limitations
			prevalence of hypothermia and the neonatal mortality rate among referred newborns		within the health district of the referral facility-tertiary level or equivalent (33%), a lower-level structure type district hospital in (20%), a first-level health center in (47%). 29/73(40%) preterm	first-level health center	of hypothermia and death.	
12. Abdulraheem et al.[30] (2016) and Olukemi et al.[31] (2020)	Nigeria	Descriptive Cross-Sectional Prospective	To evaluate the modes of transport, pre- and intratransport care of neonates referred to a tertiary neonatal care service	August 2012 to February 2013	401 neonates presenting to the emergency room of a tertiary hospital 87.3% singletons. 3.5% triplets, 9.2% twins 67.1% term 31.4% preterm and 1.5% postterm neonates 41.4% females 31.4% preterm	General or private hospitals home/mission/traditional birth attendants', primary health centers & other tertiary centers. 1 neonate was found abandoned by the roadside	No aspect of referral was adequate from communication to preparation/stabilization for transport and the actual transport itself.	
13. Ashokcoomar and Naidoo[43] (2016)	South Africa	Descriptive Cross-Sectional Prospective	To investigate delays in the transfer of neonates between healthcare facilities and to detect any adverse events encountered during neonatal transfer.	December 2011 to January 2012	120 interhealthcare facility transfers of neonates 62.2% of transfers were by frontline ambulances; 29.2% by the obstetric unit; 1.7% by the planned patient transport vehicles. 76.7% of the neonates were preterm, 85% LBW	77.5% were referred from hospitals and 22.5% were referred from primary healthcare clinics 57.5% were primary transfers for a specialized or higher level of care, 42.5% were return transfers	47.3% delays in dispatch >3 min due to ambulance nonavailability Delays in 47.3% due to no paramedic available or 32.4% of transfers where a paramedic was deemed to be required, no personnel to support the neonatal transfer on 4.7% of occasions in 15.5% no neonatal transfer equipment available.	The total study population is not known. The study was over 2 months

(Continues)

TABLE 1 (Continued)

Study ID (year)	Country	Study design	Aims and objectives	Dates of data collection	Participant demographics	Level of transfer	Conclusion	Study limitations
14. Faye et al.[37] (2016)	Senegal	Descriptive Cross-Sectional Prospective	To evaluate the characteristics of neonates transferred between 8 selected district hospitals and health centers in the Dakar region and 3 university referral hospitals	August 2013 to January 2014	130 transfers. 76.1% from peripheral centers to university hospitals and 23.8% between university hospitals. M:F 1.6:1. Preterm 37.8% LBW 33.1% 67% of transfers were for families with a low or average socioeconomic level. 42% of newborns were referred <24 h and 52% within 48 h. 8.7% were home deliveries	Between 8 selected district hospitals and health centers in the Dakar region and 3 university hospitals	Neonatal transfers are carried out in poor conditions in Dakar. The implementation of an effective neonatal transport system organized around regional. Perinatal networks are a priority.	
15. Accorsi et al.[33] (2017)	Ethiopia	Descriptive Cross-Sectional Prospective	To evaluate the cost-effectiveness of an ambulance-based referral system for emergency obstetric and neonatal care in rural Ethiopia	January to April 2015	111 obstetric cases referred to the hospital via ambulance 5% were transferred from the village via the Health center to the hospital, and 95% were referred from the health. Center to the hospital	Community to public/ private hospital	The service was undoubtedly and possibly effective for the mother and/or the newborn in 8% and 24% of cases, respectively (a total of 36 cases, corresponding to 32%). It was possibly effective for an additional 22 women and 23 newborns. Corresponding to 336 years saved. The cost per year of life saved was US$24.7 which is below the benchmarks of 150 and US$30 that define attractive and very attractive interventions.	The study exclusively focussed on survival and did not consider the quality of life and disability which may also be of relevance. The judgment on effectiveness remains theoretical and subjective

TABLE 1 (Continued)

Study ID (year)	Country	Study design	Aims and objectives	Dates of data collection	Participant demographics	Level of transfer	Conclusion	Study limitations
16. Sory et al.[40] (2019)	Guinea	Descriptive Cross-Sectional Prospective	To identify risk factors and study the causes of neonatal mortality of LBW newborns referred to a tertiary service	March to August 2015	250 referred newborns 56.4% male, 47.2% Female. Gestational age <28 weeks 28% 28–32 weeks 8.3% 32–37 weeks 6% >37 weeks 1.2% Birth weight <1 kg 9.2% 1–1.5 kg 49.3% 1.5–2.5 kg 41.6% 40.4% referred from maternity hospitals in university hospitals	All referrals to a tertiary service	45.3% of mortality in neonates admitted aged <24 h compared to 59.3% for those admitted >24 h. Risk factors associated with neonatal mortality were gravidity, parity, occupational activities requiring physical effort, birth weight, and prematurity.	The physiologic stability of neonates on arrival was not examined
17. Teklu et al.[32]	Ethiopia	Qualitative	To assess the barriers to the effective functioning of the referral system for preterm, LBW, and sick newborns across the primary health care units	December 2017 to February 2018	Mothers of premature, LBW, or sick newborns, mean age 20–29 years and primiparous, Obstetric and newborn care providers 56%—midwives and 40% nurses Facility administrators in the public health care system 74% from health centers, 26%—from primary and referral hospitals	Referrals across the 3 tiers of the public health system	Gaps and barriers in the newborn referral system were identified in 3 areas: Inadequate transport and uncoordinated referral/feedback communication between referral facilities and providers; availability of, and adherence to newborn referral protocols; and family reluctance or refusal of newborn referral. because of the expectation of infant death despite referral, and patient costs related to referral.	Mothers in one of the sample sites were not involved in the in-depth interviews due to geography and difficulty in contacting them given the limited resources available to the authors
18. Tette et al.[35] (2020)	Ghana	Descriptive Cross-Sectional	To evaluate the mode of transport, distances traveled, condition	Regional (level 2) Hospital January to	153 caregivers/parents of referred newborns.	Referrals of outborn neonates to a	The median time spent at the first referral health facility by the	

(Continues)

TABLE 1 (Continued)

Study ID (year)	Country	Study design	Aims and objectives	Dates of data collection	Participant demographics	Level of transfer	Conclusion	Study limitations
		Retrospective	on arrival and outcome of referred newborns	October 2018 District (level 1) hospital January to June 2018	Case notes reviews Male 57.5% Female 42.5% Preterm 17.0% LBW 13.7%	regional and district hospital	patients who died was four times that of those who survived. A greater proportion of neonates who died traveled by public transport (bus) and arrived in unstable conditions. Findings suggest there may have been delays initiating transfers or better stabilization required before or during the transfer.	
19. Okonkwo et al.[12] (2020)	Nigeria	Descriptive Cross-sectional Retrospective	To assess the transfer process, modes of transportation, distances covered to access care, condition on arrival, and outcomes of newborns admitted to a tertiary hospital	February 2015 to January 2016	Responsible persons for 115 babies Preterm 32.2% LBW 37.3% Male 63.5% Female 36.5%	Transfers from the community, maternity units, and peripheral hospitals into a tertiary service	Poorly developed neonatal transport system with a systematic lack of hospital-to-hospital communication from referral to accepting hospital and feedback to the referring facility. Transfers often occur without appropriate staffing, monitoring, and simple interventions.	Lack of use of standard definitions of measures of clinical stability

Abbreviations: HIV, human immunodeficiency virus; LBW, low birthweight; NICU, neonatal intensive care unit.

TABLE 2 Mode and organization of transport.

Study ID (year)	Organization	Mode of transport	Distance traveled	Travel time	Timing of referral	Vehicles and equipment	Human resources	Communication, documentation, and consent	Pretransport stabilization/ monitoring during transport	Feedback to referring units
1. Roux et al.[24] (1989) South Africa	Provincial	Neonatal ICU transfers 4 provincial and 11 private ambulance transfers	20–80 km 6 transfers <32 km	Not analyzed	No reported delays	Ground ambulances Inadequate Equipment in private ambulances	Paramedics A gap in training noted especially for private ambulances	Good verbal communication. Written communication less complete especially in private ambulances. Poor documentation of the maternal history, delivery details, and treatment before and during transport. No written consent from parents	All neonates had good Apgar scores and had vital signs checked before and after transport. No comment was made on monitoring during transport	Not analyzed
2. Njokanma and Fagbule[29] (1994) Nigeria		Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed
3. Pieper et al.[28] (1994) South Africa	Public Health Service	Aircraft and ground ambulances	Up to 200 km	Not analyzed	Not analyzed	Fixed-wing aircraft, helicopters, specially equipped ambulances	Doctors for helicopters, specially trained ambulance personnel	All transfers were planned	Not analyzed	Not analyzed
4. Ndiaye et al.[36] (2003) Senegal	Public Health Service	Ambulance used in 10% of transfers	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed
5. Enweronu-Laryea et al.[34] (2008) Ghana	Public Health Service	Mostly by taxi	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed

(Continues)

TABLE 2 (Continued)

Study ID (year)	Organization	Mode of transport	Distance traveled	Travel time	Timing of referral	Vehicles and equipment	Human resources	Communication, documentation, and consent	Pretransport stabilization/ monitoring during transport	Feedback to referring units
6. Dicko et al.[41] (2010) Mali	Public Health Service	58.6%—public transport, ambulance —17.4%	Not analyzed	Not analyzed	Not analyzed	All the newborns are transferred into the arms of a member of their family.	Health personnel accompanied newborns in ambulance transfers	No advanced communication from the referring facility in all cases. The referring personnel was a doctor in 70.3% of cases and a midwife/nurse/ caregiver/matron in 29.7% of cases.	Not analyzed	Not analyzed
7. De Vries et al.[25] (2011) South Africa	Public Health Service Regionalized Perinatal Service	State-run ambulance service	Not analyzed	Mean total prehospital time improved from 177 min in 2005 to 128 min in 2008	The mean time to dispatch is 78 min	Equipped ambulances	Ambulance crew. Personnel not analyzed	Prearranged transfers	Not analyzed	Not analyzed
8. Nalwadda et al.[42] (2013) Uganda	Public Health Service. Health Demographic Surveillance Site	Walking was the most common means used by 47% of the caretakers	The mean distance traveled was 2 km	Not analyzed	87% of newborns referred during the first week of life at a median age of 3 days	Vehicle transport not analyzed	Caretakers accompanied by transported neonates	Not analyzed	Not analyzed	Not analyzed
9. Nsibande et al.[27] (2013) South Africa	Public Health Service	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not Analyzed	Only16% of health workers gave written feedback on the outcome of the referral to the referring CHW

TABLE 2 (Continued)

Study ID (year)	Organization	Mode of transport	Distance traveled	Travel time	Timing of referral	Vehicles and equipment	Human resources	Communication, documentation, and consent	Pretransport stabilization/ monitoring during transport	Feedback to referring units
10. Katamea et al.[39] (2014) Congo	Public health service	73.3% transferred on foot. the rest 26.7% by public transport out of which taxis—22% None by ambulance	Not analyzed	Not analyzed	All newborns <7 days 43.3% were transferred more than 24 h after birth	Public transport 26.7% Equipment not analyzed	Newborns transferred wrapped and carried in the hands of a family member	In no case was the service informed in advance of the transfer	Not analyzed	
11. Nlend et al.[38] (2016) Cameroon	Public Health Service	The majority of transfers provided by the family mainly use taxis and personal vehicles, with 6.8% of ambulance transfers.	Not analyzed	The average transfer time was 17 h	60% transferred <6 h of life, 22% within the first 2 h of life. In >50%, a transfer to another hospital was done before admission		The nurse accompanied in 10/73 13.6% of transfers	Comments made about the poor chain of information is a major component of neonatal transfer and the cause of several detours	Not analyzed	Not analyzed
12. Abdulraheem et al.[30] (2016) and Olukemi et al. (2020) 31	Public Health Service	4% by ambulances 43.9% taxis 28.9% motorcycle 9% tricycles 1.7% commercial buses 10% on foot from	61.1% traveled within a 10 km radius. 6.9% traveled between 10 km and 20 km and 2.0% traveled between 20 and 80 km	Not analyzed	85% of the neonates presented in the first week of life. 33.7% within the first 12 h of life, 12.5% at 12–23 h, 9.0% at 24–48 h of life	4% transferred in hospital-owned ambulances. Ambulances were nonfunctional in 2.3% of health facilities. One ambulance was suitable to carry transport	25.0% by both mothers and fathers, 31.4% by mothers, 38.4% by fathers 5.5% by the relatives without either of the parents.	42% of the babies had referral letters while 17.3% were verbally referred from these hospitals without any letters given to them. Only 51% of the referral letters had complete information.	Pretransport care included resuscitation (18.2%), intravenous fluid/feeding (24.4%) and supplemental oxygen (14.0%). 8.7% (11/126) of preterm compared with 2.9% (8/275) of	No feedback from the referral center with any of the referring centers.

(Continues)

TABLE 2 (Continued)

Study ID (year)	Organization	Mode of transport	Distance traveled	Travel time	Timing of referral	Vehicles and equipment	Human resources	Communication, documentation, and consent	Pretransport stabilization/ monitoring during transport	Feedback to referring units
		referral centers				incubators. 62.8% of neonates were transported in the "arms of the caregivers" and 35.4% strapped to the caregivers' backs. 1 (0.2%) had a well-wrapped hot water bottle applied. None used KMC.	Only 7% of neonates were accompanied by a nurse or other health professional	There was no prior communication from any of the referring centers	term neonates died in the course of transportation	
13. Ashokcoomar and Naidoo[43] (2016) South Africa	Public Health Service	The local public ambulance provider	Not analyzed	Meantime 3 h 49 min Range 0 h 55 min to 10 h 34 min	Not analyzed	On 15.5% of occasions, neonatal transfer equipment was not available.	No paramedic was available for 32.4% of transfers where a paramedic was deemed to be required	Not analyzed	Not analyzed	Not analyzed
14. Faye et al.[37] (2016) Senegal	Public Health Service	An ambulance was used in 30% of transfers and medicalized in 3 transfers; the urban taxi was the most used mode	Not analyzed	Not analyzed	The mean delay before admission to a referral center was 3.5 h (maximum of 3 days) 53.8% had visited at	Only 3 medicalized ambulances were used. Equipment not analyzed	72.3% of transfers were accompanied only by their parents without any health personnel	Referral centers were notified in 35 cases (26.9%). In 83.9% of cases) a reference document was attached: these were essentially handwritten letters in 77.7%	39.2% had pretransfer resuscitation. 43.1% had bag and mask ventilation 13% had external cardiac massage. Resuscitation was provided by a pediatrician in	Not analyzed

TABLE 2 (Continued)

Study ID (year)	Organization	Mode of transport	Distance traveled	Travel time	Timing of referral	Vehicles and equipment	Human resources	Communication, documentation, and consent	Pretransport stabilization/ monitoring during transport	Feedback to referring units
		of transport at 45.4%			least two referral centers				2 cases. 37.7% had received no care before the referral	
15. Accorsi et al.[33] (2017) Ethiopia	Public Health Service partly financed and coordinated by an NGO	One ambulance supplied by an NGO	2.5 –47 km	Not analyzed	Not analyzed	An ambulance was equipped with a single couch but could carry up to three other seated persons if needed	Drivers with no specific training who received instructions. from healthcare professionals of the hospital or the health Centers. No healthcare professionals accompanied the driver	The call for the ambulance service was made by the pregnant woman or her family member through cell phone to the ambulance driver's cell phone or a fixed phone located at the hospital	Not analyzed	Not analyzed
16. Sory et al.[40] (2019) Guinea	Public Health Service	52.8% arrived by taxi, 33.2% on foot, 8.8% by other forms of transport and 4.8% by ambulance	Not analyzed	Not analyzed	89.2% referred < 24 h. 10.8% > 24 h	4.8% Ambulance transfers Equipment not analyzed	Not analyzed	74.4% were referred by physicians. Means of communication not analyzed	Not analyzed	Not analyzed
17. Teklu et al.[32] (2020) Ethiopia	Public Health service	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Noted as one of the major barriers to effective neonatal transport	Not analyzed	Noted as a major barrier

(Continues)

TABLE 2 (Continued)

Study ID (year)	Organization	Mode of transport	Distance traveled	Travel time	Timing of referral	Vehicles and equipment	Human resources	Communication, documentation, and consent	Pretransport stabilization/ monitoring during transport	Feedback to referring units
18. Tette et al.[35] Ghana	Public Health Service	Taxi 34.0% Bus 29.4% Motor cycless 26.8% Walked 5.2% Tricycle 2% Ambu-lance 0.7% Unspecifi-ed 1.3%	The mean distance of 23.1 km 0.93–91.15 km) for survivors and 2.69–75.66 km for those that died. 28.3% traveled <10.00 km, 26.3% 10.00–19.99 km, 42.8% 20.00–79.99 km and 4 (2.6%) traveled >80 km	Median time 1 h 20 min, Range 15 min to 48 h	9.2% < 1 day old, 40.5% < 7 days old 50.3% > 7 days old Time from onset of symptoms to arrival at the hospital 25.5% < 24 h 74.5% > 24 h	Not analyzed	Child's father 44.4% Other family member 26.1% Friend 9.1% Not indicated 1.3% One patient accompa-nied by a nurse	Not analyzed	Not analyzed	Not analyzed
19. Okonkwo et al.[12] (2020), Nigeria	Public Health Service	Tricycle 0.9%, Foot 0.9% Ambulance 3.5% Bus 13.9% Car 80.9%	10–20 km 54.7% Unknown 14.8% 20–50 km 14.8% >100 km 7.9% ≤5–10 km 7.9%	Not analyzed	Not analyzed	None of the babies were transported in transport incubators, nor given skin-to-skin care	Relative 88.7% Nurse 7.8% Doctor 1.7%, Paramedic 0.9% Pharmacist 0.9%	Most cases (75%) arrived from peripheral hospitals without referral notes or prior contact with the receiving hospitals Parents were just verbally instructed to go to the receiving hospital	There was no organized pre- or intratransfer. stabilization or medical interventions	Not Analyzed but comment made about poor feedback to referring units

Abbreviations: ICU, intensive care unit; KMC, Kangaroo mother care; NGO, nongovernmental organization.

(a) *Use of equipment, KMC, or other low-cost interventions for transport*: In no study was KMC employed during transport. In five studies using ambulance transport, there was reported inadequate equipment during the transfer[24,30,32,41,43] and one study reported on an adapted ambulance with no equipment.[33] One of these reported one neonate transferred with a hot water bottle to maintain thermal stability.[30] In all other studies, transfers were made with babies in the caregivers' arms. No study examined any innovative models for transport or used illness severity scores (TRIPS, TOPS, SNAP-II, SNAPPE-II) in assessment, triage, and prediction of mortality[44,45] (Table 2).

(b) *Human resources and family support*: The five studies which examined a regionalized/organized transport service involved trained paramedics to accompany the transfer. In all the other remaining studies, transported neonates were accompanied by mothers or other family members. A health worker accompanied a proportion of the transfers in three studies – 13% with nurses,[38] 1.7% with a doctor and nurse,[12] and 7% with a nurse or other health professional[30] (Table 2).

Referral pathway and communication: All studies reported a lack of standard referral pathways with critical deficiencies in communication before, during, and after transport with the majority reporting no communication between referring units (Table 2).

3.5 | Neonatal care and access within health facilities

Eleven studies reported on the outcome of newborns transported into tertiary neonatal units for continued care with consistently high mortality in outborn transported neonates. Only 1 out of these 11 studies reported mortalities of <10%,[35] 8 studies between 20% and 32%.[12,28,30,34,37–39,41] In one study the mortality was 46.8%,[40] with the highest mortality being 63.5%.[29] Two studies with high mortalities reported significantly increased mortalities of 44% and 51.7% in the first 48 h after delivery and transfer[29,37] (Table 3).

In relating mortality to mode of transport, one study reported an increased mortality in neonates transported by bus as compared to taxi[35] and one study reported 100% survival of babies transported by fixed-wing aircraft, compared to 70% survival if neonates transported by specially equipped ground ambulance.[28] Two studies on the compliance and effectiveness of newborn referrals made by community health workers[27,42] into health facilities demonstrated high compliance and a pivotal role of community health workers in the neonatal transfer process. One study reported on the quality of interhospital ambulance neonatal transfers[24] and another study focused on barriers to the effective functioning of referral systems for newborns,[32] reported a lack of ambulance, uncoordinated referral and communication patterns, family reluctance, and patient costs as the major aggravating factors to neonatal transfer. Five studies examined transport modalities (means of transport, the reason for transfer, transfer delay/detours, and distances traveled)[12,28,35,38,43] and reported erratic and uncoordinated transfer itinerary, increased prereferral facility transfer times, prolonged transfer times with associated high mortality in transferred neonates.

One study assessed the cost-effectiveness of a dedicated obstetric and neonatal transport service from rural areas to an established emergency obstetric and neonatal care service and reported improved neonatal outcomes associated with improved communication and a highly cost-effective service.[33]

Studies were not uniform in reporting neonatal outcomes—hypoglycemic, hypothermia, respiratory distress, and cardiovascular instability associated with the transport process aside from mortality. The studies that reported on these revealed poor outcomes. Nine studies reported on hypothermia in transported neonates albeit having differing definitions of hypothermia. Dicko et al. reported that 99% of the study population had a temperature of <37°C,[41] with the other studies reporting abnormal temperatures in 20%–67% of transported neonates.[12,29,35,37–39]

4 | DISCUSSION

This review summarizes the evidence to date on the transport of neonates in SSA. It demonstrates huge deficiencies in all the critical aspects of the neonatal transport service and a lack of adherence to established standards of transport. Infants delivered in the community or lower-level facilities continue to face uncertain journeys to higher centers of care with unacceptable high morbidities and mortalities.

A child born in SSA with a NMR of 27 deaths per 1000 live births in 2022, is 11 times more likely to die in the first month of life than a child born in the developed world. This is followed by Central and Southern Asia at 22 deaths per 1000 live births.[46]

With current high levels of neonatal mortality and only modest trends in reducing neonatal mortality in SSA, it is unsurprising that estimates by United Nations International Children's Emergency Fund project 42 of 48 countries in the region to miss the SDG neonatal mortality target by 2030. This emphasizes the need to urgently examine ways to reduce NMRs in the region hand in hand with a clear awareness of local contextual realities.[47,48]

This review found neonatal transfers in the whole subregion to be disorganized. Several studies highlighted the nonexistence of or lack of adherence to standardized pathways for the transport of sick newborns. Most transfers were effected without standard prestabilization with poor communication between referring facilities. The main ethos of neonatal transfer is to keep the neonate stable and monitored during transfer and to forestall further deterioration on arrival at the receiving hospital. Most neonates from these studies were transported in the arms of parents or family members, on public transport with no monitoring and consequently experienced disproportionately poor outcomes at the receiving facilities. Where transportation was available, there remained huge concerns about the preparedness/training as well as the adequacy of accompanying health workers. An organized neonatal transport service centered

TABLE 3 Neonatal clinical outcomes.

Study ID (year)	Mortality	Hypothermia	Respiratory distress	Hypoglycemic	Cardiovascular stability
1. Roux et al.[24] (1989) South Africa	None reported	7 neonates (pretransfer) and 11 neonates (posttransfer)—all in private ambulances had temperatures outside the normal 36–37°°C	5 out of 6 preterms	3 neonates—all in private ambulances had a blood glucose of 1.33–2.5 mmol/L pretransport and posttransport	13 neonates required. >30% oxygen during the transfer
2. Njokanma and Fagbule[29] (1994) Nigeria	63.5% 73.7% in <1.5 kg 54.6% in >1.5 kg 65% in <37 weeks 16.7% >37 weeks	Temperature <35°C Preterm 27.5% % Term 8.7%	26% of preterm	7.5% of preterm 4.3% of term	Not analyzed
3. Pieper et al.[28] (1994) South Africa	21%	Not analyzed	RDS 7 Meconium aspiration 7, pneumonia 6, peumothorax 4	Not analyzed	Not analyzed
4. Ndiaye et al.[36] (2003) Senegal	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed
5. Enweronu-Laryea et al.[34] (2008) Ghana	Survival of out-born newborns <2.5 kg improved from 56% (before) to 68% (after)	Not analyzed	Not analyzed	Not analyzed	Not analyzed
6. Dicko et al.[41] (2010) Mali	32%	759/760, 99.9% had temperatures, <37° C	13.9% Birth asphyxia 24%	Not analyzed	Not analyzed
7. De Vries et al.[25] (2011) South Africa	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed
8. Nalwadda et al.[42] (2013) Uganda	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed
9. Nsibande et al.[27] (2013). South Africa	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed
10. Katamea et al.[39] (2014) Congo	27% *Gestational age* <37 weeks 37.5% ≥37 weeks 15.7%	Infection in 49.3% Temperature instability not analyzed	Not analyzed	Not analyzed	Not analyzed
11. Nlend et al.[38] (2016) Cameroon	15/73 (20.5%)	20% had temp <36°C The mean temperature in the dead infants upon their arrival to the hospital was 35.5°	14/73 (19%)	Not analyzed	Not analyzed

TABLE 3 (Continued)

Study ID (year)	Mortality	Hypothermia	Respiratory distress	Hypoglycemic	Cardiovascular stability
12. Abdulraheem et al.[30] (2016) and Tongo et al.[31] (2020) Nigeria	4.7% certified dead-on arrival 15% died within 24 h of presentation 3.3% died between 24 and 48 h of presentation	5.1%	Apnea 9%	12.5%	Hypoxia 28.4% Acidosis 8.2% Unrecordable BP 16.5% The median TRIP score on arrival was 17 with 23% having a very severe score of >30 severe 19.4%, moderate 24.6%, and low 33%
13. Ashokcoomar and Naidoo[43] (2016) South Africa	Not analyzed	Not analyzed	Apnea 1.7% respiratory distress syndrome 40.8%	Not analyzed	Not analyzed
14. Faye et al.[37] (2016) Senegal	22.3% (29 deaths) 3 newborns were dead on arrival and 6 were in cardiorespiratory arrest 51.7% occurred during the first 48 h of hospitalization	33.8%	Present in 50% on arrival	23.8%	18.1%
15. Accorsi et al.[33] (2017) Ethiopia	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed
16. Sory et al.[40] (2019) Guinea	46.8% 95.7% in <1 kg, 39.8% 1–1.5 kg, 44.23% in >1.5 kg. *Gestational age* <28 weeks, 28% 28–32 weeks 58% 32–37 weeks 11.9% >37 weeks 1.7% *Gender* Male: 49.7% Female: 40.3%	Not analyzed	Apnea/respiratory distress in 18%	Not analyzed	Not analyzed
17. Teklu et al.[32] (2020) Ethiopia	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Not analyzed

(Continues)

TABLE 3 (Continued)

Study ID (year)	Mortality	Hypothermia	Respiratory distress	Hypoglycemic	Cardiovascular stability
18. Tette et al.[35] (2020) Ghana	7.8%	49% on arrival	Abnormal breathing patterns in 62.5%	Not analyzed	On arrival, 70.2% survivors had a normal heart rate 41.7% of those who died had normal heart rates.
19. Okonkwo et al.[12] Nigeria	Overall mortality 26.1% Preterm mortality 37.8%	<35°C 4.4% 35–37.5°C 62.6%	Gasping 1.8% <30 breaths/min 1.8% >60 breaths/min 40%	<40 mg/dL 7.7% 40–150 mg/dL 80.7%	Cyanosis 23% Hypoxia 38.3% Tachycardia 13.9%

Abbreviation: BP, blood pressure.

around an organized specialized retrieval team has been associated with improved outcomes in other studies.[47,48] For the SSA region, there is an urgent need to improve or implement district or regionalized neonatal referral and transport systems with a capacity to harness cost-effective measures to meet the demands of the health system.

Another critical piece of evidence was the acute inadequacy of relevant basic equipment where transport was available,[24,30,43] the absence of equipment in privately adapted ambulances,[33] or state ambulances,[12] as well as a lack of use of evidence-based cost-effective methods of thermal stability.

Improving the conditions of transported sick neonates should include the prevention of hypothermia by ensuring the availability of incubators, radiant heaters, heated water-filled mattresses, and KMC.[49] KMC has been recommended in a Cochrane review as an effective and safe alternative to conventional neonatal care for LBW infants, mainly in resource-limited countries.[50] A study by Sontheimer in 2004 reported that infants (preterm n = 20; term n = 11) transported in a KMC position were physiologically stable and maintained a normal body temperature during ground ambulance transport.[51] In the context of limited resources settings such as SSA, the unique benefits of KMC being an inexpensive method of maintaining physiologic stability during transport and also fostering parent-infant bonding and breastfeeding can be harnessed.

An improvement in the overall neonatal outcomes in the subregion demands a critical understanding of the dynamics of the entire transfer process within the context of the resources in the subregion. This starts from the delivery of the neonate through to the decision to transfer, the transfer itself, and feedback communication to the referring facility. Evidence from this review reveals a lack of adequate human resources at all levels of this process. Reassuringly, the studies on the role of community health workers in the neonatal care and transfer process were significant. This reinforces the need to improve training and skills in neonatal stabilization and early referral by this cadre of health workers. They could also hold an answer to circumvent some of the major barriers to the transfer process in the subregion (family reluctance and patient costs related to referral) as identified by Teklu et al.[32]

Finally, 7 years after the only systematic review in developing countries was published,[11] and halfway into the timeline for the achievement of the SDG 3 target, SSA still has a disproportionately high NMR and a dearth of well-planned studies on neonatal transport. The lack of randomized controlled studies makes the formulation of context-specific recommendations challenging. Available studies however reveal a pervasive unstructured, minimally resourced, and poorly monitored neonatal transport service with poor outcomes for transported neonates. The lack of dedicated neonatal transport teams and the heavy reliance on public transport, yet the lack of use of evidenced-based cost-effective measures of thermal stability impacts heavily on morbidity and mortality in most studies.

5 | CONCLUSION

The neonatal transport process in SSA reveals widespread inefficiencies, lack of use of standard referral pathways, and yet lack of evidence on the use of low-cost interventions in such a resource-constrained setting.

Strengthening the human resource capacity at all levels of care including the neonatal transport service, improved training and empowerment of the community health workers, effective triage and initial stabilization, and communication with referral centers may hold the key to improving the survival of transported neonates in the subregion. Large-scale implementation science evaluations for supplying appropriate transfer modes with low-cost evidence-based interventions such as KMC are required to assess the short- and long-term impact of improved neonatal transport on neonatal mortality and morbidity.

6 | STRENGTHS AND LIMITATIONS

This study summarizes to-date evidence from studies in SSA that have explored enabling or deterrent activities in the neonatal transport process. It is the only systematic review that focuses on SSA as a region in LMICs with unique economic challenges and therefore provides easily available evidence for researchers from the subregion. All the steps for conducting and reporting systematic reviews were rigorously adhered to including registration of the study protocol. Our results can serve as a guide for designing and reporting future studies in this field.

There are however many potential limitations. First, only peer-reviewed articles were included, and no search of the gray literature was conducted which may mean that additional relevant studies might have been missed. The wide heterogeneity in the included primary studies, particularly in sample size, design, definitions, and focus made it challenging for the pooling of results to enable far-reaching conclusions. The lack of well-designed studies particularly randomized control trials in this field in the subregion potentially has significant effects on the quality of the included studies.

AUTHOR CONTRIBUTIONS

Emmanuel Okai: Conceptualization; data curation; formal analysis; methodology; writing—original draft; writing—review and editing. **Frankie Fair**: Data curation; formal analysis; methodology; supervision; writing—review and editing. **Hora Soltani**: Data curation; formal analysis; supervision; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supplementary material of this article.

ETHICS STATEMENT

This article has been written in accordance with Wiley's Best Practice Guidelines on Publishing Ethics with no research misconduct. Approval by a research ethics committee was not required for this study since the review only included published and publicly accessible data. Informed consent, written or verbal was not required for this study.

TRANSPARENCY STATEMENT

The lead author Emmanuel Okai affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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3.4 Addendum to address post-viva requirements

Following the viva voce examination, it was confirmed that the systematic review constituted a narrative synthesis. It was further clarified that the PRISMA diagram should report exclusively on the narrative synthesis, rather than on both qualitative and narrative syntheses. Consequently, as noted during the thesis examination, figure 1, "Preferred Reporting Items for Systematic Reviews and Meta-analysis flowchart"—which had referenced studies included in a qualitative synthesis—requires amendment.

A revised version of figure 1, "Preferred Reporting Items for Systematic Reviews and Meta-analysis flowchart," has been appended below. Health Science Reports has been contacted to request an amendment to this figure; however, as the article has been published in its final version, they are unable to make changes to the published content. The publisher has explained that articles published with Wiley Online Library are also disseminated to and displayed on multiple indexing websites, and that they are unable to update the content held by these sites, as doing so would create data inconsistencies.

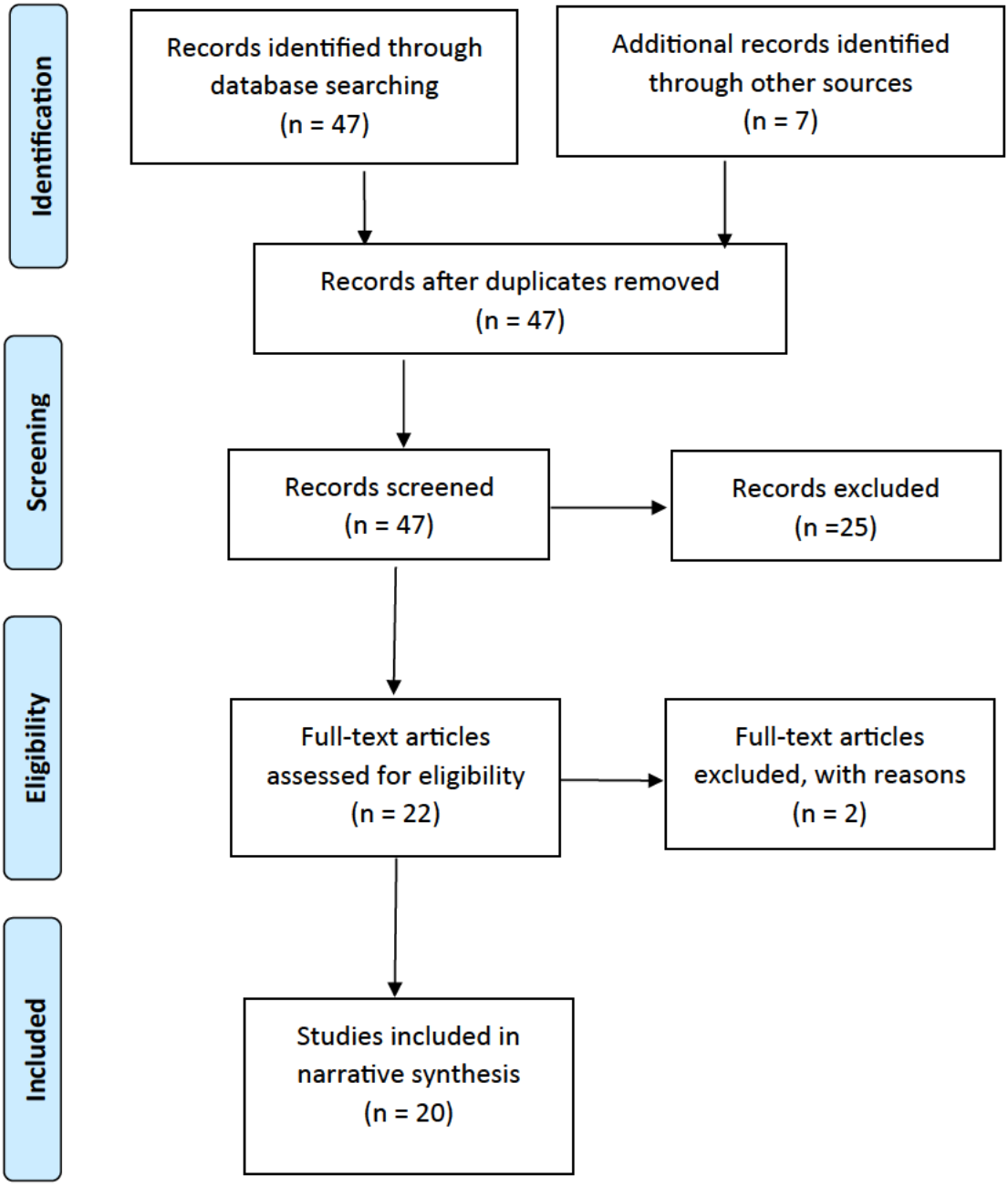

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-analysis flowchart.

3.5 Summary and implications for thesis

This systematic review was conducted with robustness, rigour, and transparency using appropriate, validated methodology and reporting in accordance with best-practice guidelines for systematic reviews. The overview's additional strengths include providing a thorough summary of the evidence by searching several databases without regard to date limits. Using the mixed methods appraisal tool, two reviewers conducted a thorough quality assessment of each included study.

This systematic review revealed poor planning, poor resourcing, and poor execution of the neonatal transport system across Sub-Saharan Africa, as well as minimal communication between facilities. Despite poor clinical outcomes among transported neonates in the subregion, the review identifies significant gaps in current research evidence, particularly regarding the use of KMC or other cost-effective interventions to improve outcomes for transported neonates.

The research gaps identified in the background literature in chapter 2 and in this systematic review are further explored throughout the remainder of the thesis.

The next chapter sets out the detailed methodology of the research programme and the approach to further exploring the identified gaps in the literature.

Chapter 4: Methodology and methods

4.1 Introduction

This chapter provides an overview of the theoretical frameworks underpinning this research programme and the chosen methods. It discusses feasibility studies, mixed-methods study designs, and the research paradigms typically connected to these approaches. The chapter provides justification for the convergent parallel mixed-methods design and the adopted paradigmatic positions, along with an overview of the research programme and ethical considerations. Finally, a synopsis of the techniques used at every phase of the research process is provided to supplement those detailed in the published publications.

4.2 Research paradigms

Researchers describe research paradigms as shared presumptions, values, and beliefs about how to understand and address problems (146). The concept of a paradigm can be applied to a field of research when there is a broad professional consensus on the philosophy, ideas, research standards, and kinds of discoveries needed in that field. A series of questions form the basis of the fundamental ideas that characterise a paradigm and, thus, a research paradigm (147). The research paradigm framework is supported by three pillars: ontology, epistemology, and methodology. Some scholars have recently begun adding another pillar to research paradigms: ethics or axiology (148).

According to Guba and Lincoln, the ontological question is the first; it concerns the structure and character of reality (149). The second question concerns the interpretation of knowledge and is known as the epistemological question. Depending on how reality is perceived, this question pertains to what can be known about it. Third, how to determine what the researcher thinks can be known in the methodological question (149). This implies

that the researcher will follow a specific set of methods or employ mixed methods to answer the research question. Axiology, in the context of research, refers to the researcher's ethical and valuable beliefs. Basic ethical principles are embedded in research paradigms and serve as a guide for researchers' decision-making (150).

Historically, the prevailing paradigms have held radically different views on the nature of reality and, therefore, on the best ways to acquire new knowledge. The positivist viewpoint asserts that regardless of a person's views or understanding, there is only one objective reality. This single reality can be understood and measured using objective, value-free enquiry (151). As a result, positivists prefer quantitative approaches and verified instruments for collecting empirical data. In contrast, the constructivist or interpretivist paradigm argues that there is no single reality or truth; instead, there are various realities that are constructed socially and interpreted by individuals (152). Consequently, data collection is required to understand the social environment, typically through qualitative methodologies that enable the researcher to comprehend these facts from the study subjects' perspectives.

Paradigms differ in their ontologies, epistemologies, and methodologies when used to represent worldviews (153). The possibility of diverse worldviews among researchers is an ongoing topic of discussion (153), especially in mixed-methods research. Variations of these two broad research paradigms exist, some of which contribute to mixed-method studies. Other research paradigms include pragmatism: something is considered real as long as it works in new, unknown circumstances, with its nature being constantly negotiated, discussed, and contextualised (154). In recent decades, critical realism has emerged as a prominent postpositivist paradigm, positioning itself as a compelling alternative to

positivism, interpretivism, and pragmatism. It is based on three core principles: a structured, mind-independent reality (ontological realism), the view that knowledge is socially constructed and fallible (epistemological relativism), and the belief that we can still rationally judge between competing theories (judgemental rationalism) (155). Accordingly, critical realism contends that observable events are caused by underlying, often unobservable, structures, and that true understanding requires analysing these generative mechanisms (155). Table 2 provides a detailed overview of the most common paradigms.

Since the philosophical epistemologies and underlying assumptions of quantitative and qualitative research are fundamentally different, some have argued that they are incompatible and cannot be combined (156,157). According to some, research paradigms offer a broad philosophical direction, but they are not entirely independent divisions (158–161). Instead, paradigms are increasingly perceived as a continuum (160,161). Therefore, many scholars have moved past the belief that qualitative and quantitative procedures cannot be integrated with each other and have proposed several ways to blend the various paradigms in mixed-methods research (160,161).

Aspect	Positivism	Interpretivism	Critical Realism	Pragmatism
Ontology (Nature of reality)	Objective, external, independent of social actors	Subjective, multiple realities, socially constructed	Objective reality exists, but is interpreted through social conditioning	External, multiple, view chosen to best answer the research question
Epistemology (What constitutes acceptable knowledge)	Observable phenomena, law-like generalizations	Subjective meanings, social phenomena	Observable phenomena provide credible data, facts. Insufficient data means inaccuracies in sensations	Either or both observable phenomena and subjective meanings can provide acceptable knowledge
Axiology (Role of values)	Value-free, researcher is detached and objective	Value-bound, researcher is part of what is researched	Value-laden, researcher acknowledges bias	Values play a large role in interpreting results
Typical methods	Quantitative	Qualitative	Mixed methods	Mixed methods, qualitative, quantitative
Data collection techniques	Highly structured, large samples, measurement	Small samples, in-depth investigations, qualitative	Methods chosen must fit the subject matter, quantitative or qualitative	Methods chosen must fit the research question
Typical approach	Deductive	Inductive	Retroductive	Abductive
Strengths	Economical collection of large amounts of data, clear theoretical focus	Facilitates understanding of how and why, good for theory generation	Overcomes weaknesses of positivism and interpretivism, recognizes importance of external world and social structures	Emphasis on practical solutions, flexibility in choosing methods
Weakness	Inflexible, artificial findings, not good for theory generation	Time consuming, difficult to analyze and interpret data, not good for generalizations	May be seen as less scientific than positivism, can be difficult to fully separate researcher bias	May lack a clear philosophical foundation, can be seen as "sitting on the fence"

Table 2: Summary of research paradigms. Adapted from Patel (2015) (162).

This research study's methodology is guided by a pragmatic research philosophy. Rather than basing their research methods solely on a particular paradigm, the pragmatic paradigm encourages researchers to base their approaches on their research questions (158). Thus, the pragmatic approach considers the feasibility of any strategy and is directed by the approaches that are best suited to addressing the research issue (158,163,164). The pragmatic paradigm emphasises shared meaning (158) and the complementarity of qualitative and quantitative approaches (163), eschewing the choice between positivism and constructivism (153). It combines evidence from several sources to provide viable answers or courses of action for the issue under study (165).

The work of John Dewey (166), who aimed to reorient the philosophy of knowledge away from abstract concepts and towards a focus on human experience, had a significant influence on pragmatic education. According to one theory, the foundation of human

experience is based on two questions that are constantly connected in a cycle: 'Where do our beliefs come from?' and 'What do our behaviours mean?', whereby our beliefs guide our behaviour, and our actions, in turn, influence our beliefs. Dewey classifies experiences as self-conscious decision making (enquiry) and relatively automatic, thought-free events known as habits. Conscious enquiry occurs when an experience becomes difficult or unfamiliar. These conceptions of the human condition also emphasise the significance of personal sentiments and the impact of other people on attitudes and behaviour. Since humans are inherently social and emotional beings, pragmatists differ from other thinkers who focus on philosophical debates about the nature of reality and truth by emphasising human experience.

As reported by Wasti *et al.* (167), mixed-methods research combines questions from the two primary ideologies in what is referred to as the third path (168), third research paradigm (169), or the third methodology movement.

4.3 Mixed methods research

As previously described, the research question serves as the primary guideline for a pragmatic philosophical approach to research, meaning that the selection of methods focuses on those that provide the most comprehensive answers to the research issue. This makes it the paradigm most frequently linked to mixed-methods research, in which researchers employ both qualitative and quantitative approaches to solve the study problem (164). Mixed-methods research emerged from the understanding that not all knowledge-gathering techniques are perfect and that it can be advantageous to use a variety of approaches (171). This is particularly crucial for complex social phenomena (171).

Despite the lack of a formal definition of mixed-methods research (169), Tashakkori and Creswell provide a broad definition as "research in which the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches" (172). Creswell proposed four core characteristics of mixed-methods research that have been widely accepted (153).

1. It rigorously gathers quantitative (closed-ended) and qualitative (open-ended) data to answer a particular research question.
2. These are integrated into a particular research design that offers the steps for carrying out the investigation.
3. Theory and philosophy serve as the frameworks for the procedures.
4. The results obtained from the two methods of gathering data are integrated.

Mixed-methods research has several benefits. The findings are more than the sum of their parts (160). Better insight into the research problem (153) is gained by combining statistical analysis with a deeper understanding of concepts derived from qualitative methodologies rather than conducting two independent studies in isolation. This enables a more thorough exploration of complex clinical issues based on well-conducted, rigorously designed mixed-methods studies than can be achieved with conventional quantitative or qualitative approaches alone. Mixed methods allow researchers to ask exploratory and confirmatory questions simultaneously, thus enabling the generation and verification of theory within the same study (160) through the process of 'following a thread' (173). This unique ability enables rapid, iterative questioning and answering. Additionally, research using mixed methods offers greater opportunities for triangulation (174).

There are drawbacks to mixed-methods research. A significant limitation of mixed methods is the additional time required to conclude the overall study, especially with sequential designs (175). This should be addressed earlier in the development of the study, as collecting data, analysing, and interpreting results from two or more studies takes significant time. Individual researchers may lack the skill set necessary to conduct a mixed-methods study, necessitating the involvement of additional researchers to assist with the project (175).

Due to the recent history of mixed-methods research, it can be challenging to assess the quality, validity, and reliability of the meta-inferences produced (160). It has been suggested that the quality of design and interpretive rigour must be appraised to ascertain the quality of inference within the 'integrative framework for inference quality' (160). A mixed-methods reporting guideline, proposed as guidance, is the Good Reporting of a Mixed Methods Study (GRAMMS) criteria (176).

Another limitation is the publication process: many journals impose word limits, making it challenging to include an entire mixed-methods study within the limits without compromising necessary detail. Adding data as a supplemental file or publishing the studies independently are both practical options, but caution must be exercised to maintain the level of integration. The intrinsic strength of conducting mixed-methods research may be undermined if studies published separately within a mixed-methods approach yield results that are "the sum of its parts" rather than "more than the sum of its parts" (177). The adoption of a different publication model as the dissemination strategy necessitates a thorough description of the meta-inferences and a detailed explanation of the degree of integration attained (178).

The use of mixed-methods research has been gathering significant momentum in recent years. Mixed-methods research is used in health research for its inherent ability to provide a holistic picture in which meanings derived from interviews or observations complement the prevalence of traits in a population as measured by surveys. These add depth and breadth to the study, and, in summary, align with the evolution of evidence-based practice (167).

As described in previous chapters, transporting newborns in a limited-resource setting is a complex process that is beset by many challenges. Employing KMC without altering existing modes of transport would require a research approach to address this complexity.

4.3.1 Major mixed methods designs

The classical typology used to classify mixed-methods designs divides them into two principal categories (179): sequential and concurrent. In a sequential design, the process is divided into two stages: qualitative or quantitative data are collected in the first stage, and the other data type is collected in the second stage. In the concurrent approach, both types of data are collected in the same development step. More in-depth studies have emerged in recent years that discuss decisions on priority, timing, and the degree of integration of qualitative and quantitative data. Creswell and Clark (153) presented one of the key reference works on mixed-methods research, introducing the phases of the mixed-methods research process and proposing four specific mixed methods designs, summarised in Table 3.

Design Type	Variants	Timing	Weighting	Mixing	Symbols
Triangulation	❖ Convergence ❖ Data transformation ❖ Validating quantitative data ❖ Multilevel	Concurrent quantitative and qualitative data collection	Usually equal	Merge the data during the interpretation or analysis	QUAN + QUAL
Embedded	❖ Embedded experimental ❖ Embedded correlational	Concurrent or sequential	Unequal	Embed one type of data within a larger design, utilising the other type of data	QUAN(qual) or QUAL(quan)
Explanatory	❖ Follow-up explanations ❖ Participant selection	Sequential: Quantitative followed by qualitative	Usually quantitative	Connect the data across the two phases	QUAN→ qual
Exploratory	❖ Instrument development ❖ Taxonomy development	Sequential: Qualitative followed by quantitative	Usually qualitative	Connect the data across the two phases	QUAL→ quan

Table 3: The major mixed-method designs. Adapted from Creswell and Clarke (2007, p. 85)

In addition to the major design methods described above, several complex mixed-method designs have been proposed. Johnson *et al.* (169) and Bergman (180) extended and combined the classical approach, proposing six design approaches based on sequential and concurrent approaches. Onwegbuzie and Collins (181) extended the traditional conceptualisation of mixed-methods research, which typically involves an independent qualitative and quantitative study, by proposing the application of three or more qualitative and quantitative studies. This suggestion led to the emergence of a multiphase, or iterative, mixed-methods research design.

Cresswell and Clark have updated the typology of core designs and suggested three core mixed methods designs to give researchers a framework, given the wide variety of classifications available and the evolution of the mixed methods field (153).

1. **The convergent design,** formerly known as concurrent or parallel design, is utilised when a researcher aims to combine or compare the findings of both quantitative and qualitative data analysis. The fundamental concept involves comparing the two outcomes to gain a more comprehensive understanding of an issue, to validate one set of findings against another, or to determine whether participants respond similarly to open-ended qualitative questions and predetermined quantitative scales. Essentially, the two databases are merged (153).
2. **The explanatory design,** also referred to as the explanatory sequential design, unfolds in two distinct interactive stages. The first stage involves quantitative data collection and analysis. This is followed by the gathering and examination of qualitative data to enhance the quantitative findings. The structure of the qualitative phase is designed to flow directly from the quantitative phase's findings.
3. **The exploratory sequential design,** also known as the exploratory design, employs sequential timing. Unlike the explanatory design, the exploratory sequential design focuses on collecting and analysing qualitative data in the initial phase. The researcher then uses the qualitative results to design a quantitative feature during the development phase. Finally, the researcher quantitatively tests the new feature in the third stage and analyses how the quantitative findings complement the original qualitative findings (153).

4.3.2 The convergent parallel design

One of the best-known approaches to mixed-methods research is convergent design (169). It was originally defined as a "triangulation" design, but the term is often confused with triangulation in qualitative research, and the design is frequently used by researchers when triangulated findings are not the goal. This design has been called various names over the

years, including 'parallel study', by Tashakkori *et al*. (164). The design involves collecting and analysing quantitative and qualitative data separately but often simultaneously (182). The separate findings are merged through various techniques. The convergent design is initiated to "get different but complementary data on the same topic" (183) to fully understand the research problem. In this model, the weight can be assigned to either the quantitative or the qualitative aspect, or to both equally. The merging of the two methods occurs either during data analysis or during the interpretation of the results from the two parts of the study.

Several approaches can be used for data analysis. The prevailing method is to contrast the quantitative results and findings from qualitative research to corroborate or cross-validate findings derived from the entire study (183). Another popular method involves converting qualitative data into quantitative data by quantifying (counting codes, categories, and themes) or transforming quantitative data into qualitative data by qualifying (using cluster or factor analysis), allowing for direct comparison with another data set or inclusion in the overall analysis (184). To discuss whether the results from both study components converge or indicate divergence, the researcher discusses the collection and analysis of quantitative and qualitative data in distinct sections, but merges the interpretation of the quantitative and qualitative findings into one piece (177).

This design has several advantages. A key advantage of using a convergent design is that quantitative and qualitative data can be collected simultaneously, which reduces the time taken compared to a sequential design (182).

The methods typically associated with each type of data can be used to collect and analyse it independently. This allows for collaborative research, in which team members with both quantitative and qualitative skills can be included (153).

The design allows for the direct comparison of participants' perspectives gathered through an open-ended questioning format (e.g., a semi-structured interview) with those derived from the researcher's viewpoint in closed-ended questioning. This approach enables researchers to give participants a voice while reporting statistical trends (153).

On the other hand, there are inherent design weaknesses. The analysis process is arguably more complex, particularly during data transformation (184). When merging the two datasets, researchers must consider the consequences of having different samples and sample sizes. Variations in sample sizes may arise because quantitative and qualitative data are typically collected for different purposes (153).

4.4 Pilot and feasibility interventional studies

Recently, recognition of the importance of preliminary work before organising large, publicly funded randomised-controlled trials has grown. Researchers are encouraged to share pilot findings before their main trials, and some publishers are willing to publish these results. However, confusion about the purpose and terminology of the preliminary work remains (185).

The NIHR Evaluation, Trials and Studies Coordinating Centre (NETSCC) defines a pilot study as a miniature version of the main study that determines whether the components of the main study can work together (185). Epidemiology and statistics dictionaries similarly define a pilot study as a small-scale test of methods for larger-scale applications, contingent on its success (186).

NETSCC defines feasibility studies as those that estimate parameters essential to the design of the main study, including the standard deviation of the outcome, patient willingness to randomise, clinician recruitment readiness, number of eligible participants, follow-up rates,

response rates, and adherence rates. Feasibility studies may lack a plan for further work and may aim to evaluate the feasibility of a full-scale study (185).

Essentially, the difference between a feasibility study and a pilot study is that a pilot study functions as a smaller version of the main study and is designed to test whether all components of an intervention can work together. In contrast, feasibility studies do not evaluate the outcome of interest. Instead, they focus on estimating the parameters needed for designing the main study (187).

Failing to conduct a feasibility study before a full-scale RCT may jeopardise its original aims and objectives. For instance, it might face challenges in recruiting participants or in effectively delivering intervention and trial procedures (188). Through a feasibility study, researchers can assess the study's methodology. Considering the number of participants available and their willingness to participate, researchers will also be able to determine recruitment and retention rates (189). The researcher can gather pilot data on, for instance, the time required to complete the questionnaire or the expenses associated with entering the data into a computer by measuring the resources needed, including time and money. It is possible to analyse management concerns, such as the recruitment centre's organisation of personnel and data. This process enables the examination of scientific questions, such as outcome measures, and the testing of the suitability of research tools (questionnaires and data collection forms). Before broader utilisation, it can also enhance the internal validity of surveys (190). Feasibility studies, unlike randomised-controlled trials, typically do not require formal power calculations for hypothesis testing. They primarily assess the viability of a larger study rather than confirming an intervention's effectiveness (191).

The updated UK Medical Research Council's framework for developing and evaluating complex interventions (Figure 11) outlines the importance of feasibility testing and details the intervention development stages (192).

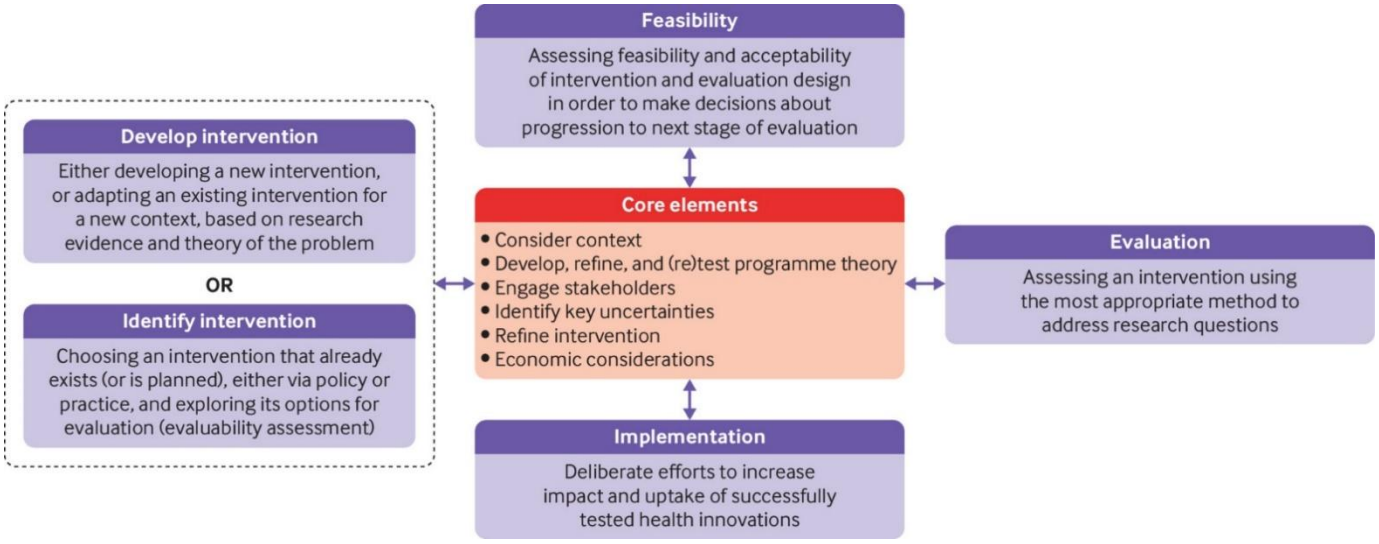

Figure 11: Framework for developing and evaluating complex interventions (192)

It recommends a mixed-methods design combining quantitative and qualitative methods. This approach is better for informing future full-size trial design (193) and enhancing understanding of research findings (193).

4.5 Cluster-randomised trials

Cluster-randomised trials (CRTs) are experimental investigations in which intervention groups are randomly assigned to intact social units (clusters), such as families, schools, or even entire towns, rather than to independent individuals (195). CRTs were infrequently utilised before the mid-1980s; however, their popularity has significantly increased over the past two decades, especially in the assessment of healthcare innovations, with remarkably rapid growth noted from the mid-1990s, as shown in Figure 12 below, adopted from Bland (196).

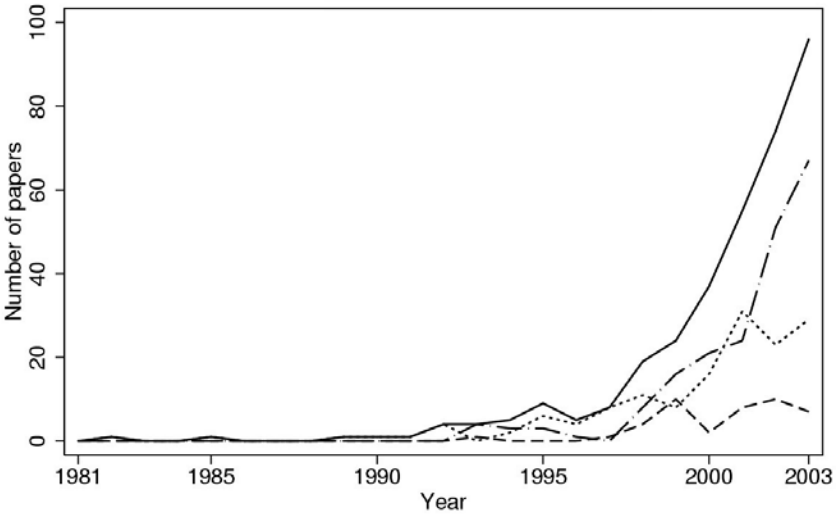

Figure 12: Cluster-randomised trials published 1981–2003
Source: Bland JM. (2004). "Cluster-randomised trials in the medical literature: Two bibliometric surveys." BMC Medical Research Methodology; 4: Figure 1, p. 4.

Published CRTs exhibit significant variability in intervention selection, randomisation units, and sampled populations. Cluster-randomised trials are generally acknowledged to be suitable for evaluating various interventions, including educational programmes aimed at health professionals rather than individual patients, community-based health promotion programmes, and family-based dietary interventions (196). Researchers commonly recognise that observations from the same clusters are more similar to each other than observations from different clusters; therefore, this correlation requires consideration to avoid inflated Type I error rates and overly narrow confidence intervals (196).

Scientists have long considered randomised trials the pinnacle of scientific evidence. However, in some contexts, there are sound reasons to randomise by groups or clusters, which offer logical benefits over randomising by individuals. The best way to evaluate the efficacy of an intervention is to assess it in a "real-world setting". Since many interventions may benefit both a group and an individual, cluster randomisation simplifies this process compared to individual randomisation (197). Additionally, compared to individual randomisation, cluster randomisation may have substantial logistical, ethical, or practical

benefits. In a CRT, researchers randomly assign whole villages to control or study interventions; this is simpler than in an RCT, where researchers randomly assign residents from multiple villages. Another advantage of using CRT is the reduced possibility of cross-contamination among patients or individuals (198).

A significant disadvantage of CRTs is that many cluster-randomised trials lack sufficient clusters to ensure balanced treatment arms. Some have argued that incorporating crossover into a cluster-randomised study can improve logistical and statistical efficiency (197). While cluster randomisation is frequently recommended to reduce treatment "contamination" among intervention and control participants, it is not foolproof. Researchers should consider the risk of contamination during trial design and select an approach that effectively mitigates this risk (199).

A variety of methods can be used to analyse data from these studies, but the key is that the experimental unit (cluster) is the unit of analysis. Three broad categories of analysis can be used for CRTs: cluster-level analyses, generalised linear mixed effect models (GLMM), and generalised estimating equations with sandwich standard errors (GEE) (200). Finding a summary statistic for every cluster is the simplest (201). Typically, this is the proportion of a binary outcome or a mean for a continuous outcome. In a GLMM, a random effect for a cluster is included to directly capture the correlation among observations within the same cluster. For observations in the same cluster, GEE assumes a functioning correlation structure, and standard errors are computed considering the observed correlations in the data (200).

4.6 Methodology within this thesis

This thesis presents research exploring the feasibility of employing KMC for neonatal transfer without altering the existing mode of transfer in a Sub-Saharan African country. This intervention sought to leverage the benefits of KMC, a cost-effective intervention recommended by the WHO for limited-resource settings, to improve outcomes for preterm and LBW infants during transfer, as its use is currently limited to inpatient care of newborns in neonatal units across the region.

Preterm and LBW neonates delivered to mothers in the catchment area of the Cape Coast Teaching Hospital (CCTH) and due for transfer were offered the choice of transfer using KMC or conventional methods, utilising their selected mode of transport.

The study employed a convergent parallel mixed-methods approach, collecting simultaneous quantitative data to determine the impact of KMC on the outcomes of transported neonates. Additionally, qualitative data were gathered through semi-structured interviews to explore the experiences of mothers and participating healthcare professionals, complementing the interpretation of the quantitative results and assessing the practicality and acceptability of the intervention.

The study results are reported in two distinct phases before being synthesised in a final discussion of the findings. An overview of the research design is illustrated in Figure 13. This thesis presents each component of the investigation using an article-based format. Consequently, each article thoroughly details the methods used for each component. This chapter provides a summary of the study's integrated elements.

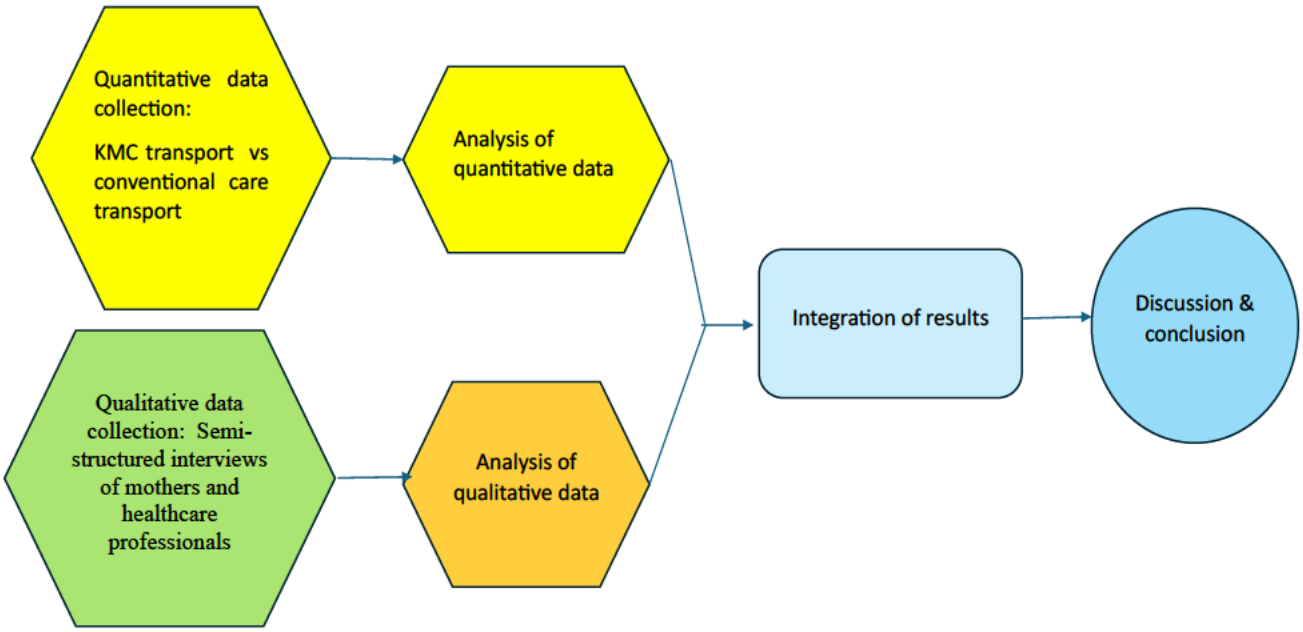

Figure 13: Research design

4.6.1 Cape Coast as a study site

Ghana is a lower-middle-income country located along the Gulf of Guinea in West Africa, with a total population of approximately 31 million (11). At the time this study was implemented, there were 16 administrative regions in the country. The country operates a universal national health insurance scheme that provides free healthcare and all citizens are encouraged to register to enjoy the benefits. The country has a national ambulance service that provides pre-hospital emergency medical care and transportation. Despite sustained growth in the ambulance service over the years, coverage remains low, even in the capital, Accra, where the ambulance-to-population ratio is approximately 1:250,000—a ratio 5 to 10 times below expert-recommended levels for lower-income countries (9,119). Public utilisation also remains low, as the current norm is to transport the injured or ill to the hospital in private vehicles and taxis due to the belief that taxis are faster than ambulances

(9). The study area, Cape Coast, serves as the regional capital of the Central Region, one of Ghana's 16 administrative regions. As a metropolitan district, Cape Coast offers health facilities at various levels of care, with the Cape Coast Teaching Hospital, where this study was conducted, serving as its tertiary referral centre.

The hospital oversees approximately 2,800 births per year. At the time of this research, the neonatal unit could provide continuous positive airway pressure ventilation support, oxygen, incubator care, radiant warmers (often shared), and phototherapy. KMC is routinely utilised in CCTH for the care of stable newborns preparing for discharge, and nurses in the unit receive regular in-service training on KMC to enhance their practice. However, the intervention has not been used previously for neonatal transfers in Ghana. Participants (mother–baby pairs) were recruited into the study by trained health professionals from eight sites with the highest referrals to CCTH from August 2022 to April 2023. Four of these sites were designated as intervention sites to employ KMC for transport, while the remaining four served as control sites using conventional transport methods. The study sites were selected to achieve an optimal balance of socioeconomic status, maternity unit size, ethnic diversity, and distance from the special care baby unit in CCTH. Details of the study sites are provided in the methods and results sections of the published Article B.

A detailed questionnaire, including information on demographic characteristics and pregnancy and delivery histories, was collected from all participating mothers using a standardised pro forma. A copy of the baseline questionnaire is shown in Appendix D. Birth weights, gestational ages, and physiological measures following transport to CCTH were also recorded. The anonymised data collected are available as open data via the Open Science Framework repository: https://doi.org/10.17605/OSF.IO/P9HVK.

4.6.2 Qualitative component

The qualitative aspect of the research utilised semi-structured interviews to explore the experiences of mothers who employed KMC during neonatal transportation, as well as those in the conventional care cohort. These interviews explored the viewpoints of both the mothers and the participating healthcare professionals concerning the obstacles and facilitators involved in integrating the intervention for transferring neonates with existing transportation options and neonatal care in CCTH. The interview methodology was designed for face-to-face execution, capitalising on its distinct benefits. These include the capacity to observe nonverbal communication, establish a stronger rapport between researchers and participants, and enable a flexible line of enquiry. Such real-time engagement is critical to a nuanced, contextual understanding of the subject matter.

Qualitative studies align with the philosophical presuppositions of constructivism. For this project, however, a convergent parallel mixed-methods design was utilised, which is grounded in the philosophical assumptions of pragmatism (170,205). The interviews aimed to understand how mothers and healthcare workers interpreted their experiences with KMC transport.

4.6.3 Statistical analysis

4.6.3.1 Rationale for the use of cluster-level analysis

The details of how specific methods were used in each phase of the data analysis are given in the published papers and, therefore, will not be repeated here. The primary interest of this research was to determine the feasibility and acceptability of employing KMC in the neonatal transfer process. Data collection and analysis focused on clusters of preterm and LBW infants for whom KMC has been recommended for use by the WHO. By keeping the clusters for analysis and maintaining a significant distance between the intervention and

control groups, it was possible to evaluate the intervention's feasibility with reduced cross-contamination among participants.

Cluster-level analysis was used, and the observations from each cluster were summarised. These cluster-level summaries were analysed using simple methods for independent data, such as means and proportions. It is well known that cluster-level analysis, often using a simple *t*-test on aggregated cluster summaries, effectively controls Type I errors in trials with few clusters and non-normal outcomes (202,203). As recommended by Thompson *et al*. (200), in cluster-randomised trials with 30 or fewer clusters and a binary outcome, an unweighted cluster-level analysis or GLMM is preferred. For this feasibility study, we opted not to use GLMM in the analysis because statistical inference was not our main focus; rather, we aimed to assess the intervention's feasibility in this context.

The identified potential confounding variables included the care provided to transferred neonates in CCTH, which may influence mortality rates between the two groups and requires investigation in a larger study. Furthermore, discrepancies in travel distances and the absence of precise travel time data between the two groups may introduce biases that could directly influence the outcomes.

A formal power calculation based on detecting evidence of effectiveness was not performed because the study was a feasibility study trial. Based on data from our published work in Abgeno *et al.* (204) in a 10-year review of admissions and discharges from the neonatal unit at CCTH, I anticipated recruiting 60 mother–baby pairs over 6 months in the intervention arm, and the same number from the control sites. This was a practical sample size chosen to identify evidence of feasibility and practicality while addressing any issues with recruitment rates.

4.7 Data sharing, ethics, and consent

Autonomy, beneficence, non-maleficence, and justice are the four primary ethical concepts that should be considered when conducting research (206). Autonomy guarantees that people are regarded as capable of making their own decisions or safeguarding them if they are not (207). Obtaining informed consent and voluntary participation are crucial to accomplishing this. The principles of beneficence (maximising potential benefits) and non-maleficence (doing no harm) ensure that the researcher prioritises the participants' welfare while conducting the study, maximising potential benefits and minimising potential harm (207). Justice ensures that every participant is treated fairly in terms of inclusivity and the equitable distribution of any advantages or costs associated with the study (207).

One significant advantage of cluster randomisation over individual randomisation is that it offers substantial logistical, ethical, and practical benefits. Ethical approval for both the quantitative and qualitative aspects of the study was obtained from The Cape Coast Teaching Hospital Ethical Review Committee (CCTHERC) - REF: CCTHERC/EC/2021(053 as well as Sheffield Hallam University Ethics Committee (Ethical Review ID: ER46927191), which is available in Appendix E.

Participants were provided with written information regarding the study. A copy of the participant information sheet is available in Appendix F. At the referral centres, mother–baby pairs who gave their consent (Consent form – Appendix G) were recruited by trained research staff, including nurses and midwives. Nurses and midwives involved in the initial triage of babies admitted to the special care baby unit at CCTH, as well as the mothers, also gave consent for the semi-structured interviews. Both the consent and participant information forms were translated into the local language.

Written, voluntary consent was obtained before the interviews began, and participants were given the opportunity to ask any questions they had about the study. The written material and the consent form reaffirmed that participation in the study was entirely optional and would not affect their child's present or future medical care.

All interviews were conducted and digitally recorded in English or in the participant's chosen language (Fanti or Twi). A member of the research team transcribed the recordings verbatim. The transcript findings were reviewed and rechecked against the recordings to ensure accurate interpretation of the data using the exact words of the participants. The digital recording of the interviews was implemented to ensure that all necessary details were captured and to minimise recall bias. It also allowed the focus to be on the interview's content.

Qualitative data obtained from the participants were anonymised for analysis. All identifying information was removed from the transcripts, including any mention of participants' names, places of employment, or residences. Throughout the study, audio recordings were maintained on file; thereafter, only anonymised transcripts were retained. Paper-based data were stored securely at the special care unit of CCTH and were accessible only to the researchers. Contact details were destroyed when no longer needed. All electronic data were stored on password-protected laptops in a project-specific folder designated solely for research data. This information was accessible only to the research team. Only members of the research team could access the secured filing cabinet containing physical data, including signed consent forms. To prevent identification, consent forms were stored in physical form, while transcripts were maintained electronically.

No funding sources were available for this research study.

4.8 Summary

This chapter covered the concepts of philosophical research paradigms and justified the research methodology employed in this programme, including the convergent parallel mixed-methods approach.

It described the philosophical foundations and theoretical frameworks of the study. A brief background on the justification for using a feasibility study and a cluster-randomised trial in this cohort within a limited-resource setting, across both the quantitative and qualitative phases, was provided, along with an explanation of the statistical techniques used in the study and the rationale for their selection. Additionally, the research project's ethical considerations were discussed.

The following chapters present the two primary studies that comprise this research programme. The studies were presented as published research articles in their original form.

Chapter 5: Feasibility of the use of Kangaroo Mother Care in the transfer of preterm and low birth weight infants

5.1 Introduction

This chapter presents Article B, the quantitative component of this programme of research, which examines the feasibility of comparing the outcomes of preterm and LBW infants transported using KMC with those transported using conventional care in Cape Coast. The aim of the study is provided, followed by a copy of the full published research paper in its published form. The chapter ends with a synopsis of the main ideas, the measurable impact of the work, and a discussion of how it contributes to the thesis.

As discussed in chapter 2, there is a growing body of evidence indicating that neonates transported under sub-optimal conditions have higher rates of mortality and more adverse effects on physiological outcomes. There is a dearth of information on the use of KMC or other cost-effective interventions in neonatal transport in developing countries, with current data largely from studies conducted outside Sub-Saharan Africa, which unfortunately has one of the highest neonatal mortality rates in the world.

This study aims to contribute to the existing body of evidence by comparing outcomes in neonates transported using KMC with those transported via conventional care, without modifying the mode of transportation, in Cape Coast. This investigation, distinctive in its methodology, examines the application of KMC in neonatal transportation in a manner not previously documented within the subregion, thereby offering an opportunity to add novel insights to the field of research and to stimulate renewed interest in the topic.

This study contributes to fulfilling the second research objective outlined in chapter 1:

> **Assess the feasibility of employing KMC in the transport of preterm and low birth weight neonates in Ghana using a non-randomised cluster feasibility study.**

5.2 Published paper: Article B

The published paper titled *"Feasibility of the use of Kangaroo Mother Care in the transfer of preterm and low birth weight infants: A two-arm non-randomised controlled cluster feasibility study of neonatal transport in Cape Coast, Ghana"* is reproduced here in the same format as it was published online.

5.3 Publication and impact

The manuscript describing this study was accepted for publication in *BMC Pediatrics* in December 2024. *BMC Pediatrics*, a renowned international open-access journal, publishes peer-reviewed research articles covering all aspects of healthcare in neonates, children, and adolescents, as well as related molecular genetics, pathophysiology, and epidemiology. With a Journal Impact Factor of 2.0 and a 5-year Impact Factor of 2.4, the journal's recognition further affirms the credibility of this study. According to Google Scholar, the article has been cited three times since its publication online (as of 26 May 2025).

BMC Pediatrics

RESEARCH

Open Access

Feasibility of the use of Kangaroo mother care in the transfer of preterm and low-birth-weight infants: a two-arm nonrandomized controlled cluster feasibility study of neonatal transport in Cape Coast, Ghana

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Abstract

Background Despite progress made towards SDG 3, sub-Saharan Africa lags behind the rest of the world, accounting for over 50% of global neonatal deaths.

The increased number of hospital births in the region has not reciprocated the reduction in neonatal mortality rates. Sick newborns face uncertain journeys from peripheral facilities to specialized centres arriving in suboptimal conditions, which impacts their outcomes, due partly to the scarcity of dedicated neonatal transport services.

Methods This was a 2-arm nonrandomized controlled cluster study of preterm and low-birth-weight neonates transferred from eight peripheral sites to a tertiary neonatal unit via conventional methods or the KMC (August 2022–April 2023).

Results A total of 77 (mother-baby pairs) were recruited, 34 in the KMC group and 43 in the conventional arm. Most (60%) were transported by taxis/private cars. Overall mortality was 20.8%. No untoward event was recorded for neonates transported by KMC, with marginally better temperatures on arrival. Although the observed differences were not statistically significant given that this was not the primary aim, the findings add to evidence that KMC transport may not be more life-threatening than the current practice of transporting newborns in the caregiver's arms. KMC transport has the added advantage of ensuring non-separation of the small and sick child from its mother from birth and improved temperatures upon arrival.

Conclusion KMC transport for preterm and Low birth weight infants using available transport in Sub-Saharan Africa is feasible. Local large-scale randomized trials are needed to gather more evidence for policy direction needed to inform a scale-up of this low-cost intervention.

Trial registration ISRCTN98748162. Retrospectively registered 02.09.2024.

Keywords Kangaroo mother care, Prematurity, Low birth weight, Neonatal transport, Low- to middle-income countries, Sub-Saharan Africa

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Background

Progress towards reducing newborn mortality worldwide has stagnated compared with reductions in maternal and under-five childhood mortality over the past three decades [1]. The United Nations Sustainable Development Goals (SDGs) target 3.2 is laudable for all countries to reduce neonatal mortality to at least 12 per 1,000 live births and under-five mortality to 25 per 1,000 live births by 2030 [2]. Despite the worldwide adoption and progress made towards SDG 3, sub-Saharan African (SSA) countries, with some of the weakest health infrastructure in the world, continue to fall behind most of the world. In 2022, approximately half (47%) of all deaths in children under 5 years of age occurred in the newborn period, with SSA accounting for 57% of these deaths but only 30% of global live births [3]. Current projections estimate that sixty-three countries, almost three-quarters of which are in SSA, will miss the SDG 3,2 target by 2030 unless they double or triple their current progress [4].

Ghana has a population of 30.8 million, with a rapidly urbanizing and youthful population: 35% are children (0–14 years), and 38% are young people (15–35 years) [5]. Ghana's commitment to accelerating its efforts towards achieving the SDG NMR target has inspired its subscription and commitment to several global standards, including the Global "Newborn Action Plan" in 2014, "Every Woman Every Child" in 2015, the Ghana National Newborn Care Strategy and Action Plan, 2019–2023, "WHO standards of care for small and sick newborns" and the "Global Initiative for Quality of Care for Maternal and Newborn Health" [6–8]. Consequently, coverage of maternal and newborn health services has improved in Ghana over the last decade, but progress towards the SDG NMR target remains slow, and neonatal mortality remains an important public health challenge in the country. The neonatal mortality rate in Ghana decreased from 29 per 1000 live births in 2014 to 17 per 1000 live births in 2022 [9]. Eighty-six per cent of live births and stillbirths took place in a health facility in Ghana according to the 2023 GDHS, with 88 per cent of live births and stillbirths assisted by a skilled provider, up from 76 per cent in 2014 [9].

Specialized neonatal services remain a major challenge in many LMICs, including Ghana, with the few existing services concentrated in urban areas. Owing to this poverty of neonatal critical care services, critically ill neonates are transferred frequently over vast distances, mostly in the arms of caregivers [10]. Consequently, transferred neonates face an uncertain journey in many LMICs, with numerous studies describing higher rates of adverse outcomes and increased mortality [11–13]. The admission temperature of newborn babies during all gestations is a strong predictor of morbidity and mortality, especially for preterm and very small babies [14, 15]. Hypothermia is associated with increased mortality and morbidity in newborns [16], and admission temperature is inversely related to in-hospital mortality [17]. For every degree below 36.5^0 C, the mortality risk increases by up to 28% in low-birth-weight newborns [18]. A dedicated and specialized neonatal transport service involving the use of ambulances and transport incubators is beneficial for thermoregulation and maintenance of physiological stability in transported neonates but cost-intensive and unavailable in many developing countries [19, 20]. Incubator transport is moreover not without risks. Studies have documented an increased risk of intraventricular haemorrhage (IVH) caused by mechanical effects such as shaking or vibration of the head, instability of temperature and blood pressure [21] and eminently the lack of practice of Family-centred care (FCC), including skin-to-skin care which aims to overcome the negative effects of separating the parents and their infant [22–24].

Kangaroo mother care(KMC) is a method of care in which the infant is carried in a skin-to-skin position with the mother/caregiver. It was developed out of necessity in Bogota, Colombia in 1979 and used as a substitute for incubators for preterm neonates to address the shortage of caregivers and the lack of resources. Initially designed as an early, prolonged, and continuous skin-to-skin contact between the mother and the low birth weight (LBW) newborn infant until 40 weeks postnatal age [25] , it has evolved into its present state as a form of parental caregiving where the LBW neonate is intermittently nursed skin to skin in a vertical position between the mother's breast or against the father's chest for a nonspecific period [26].

Several hospital-based and community studies on KMC have demonstrated its many benefits, including strengthening the mother-baby bond, promoting breastfeeding, preventing hypothermia, reducing nosocomial infection, and increasing early discharge from the hospital [27–29].Studies on the physiological outcomes of newborns undergoing KMC have shown beneficial outcomes including efficient gas exchange [30], stable respiratory functions and pulse oxygenation [31, 32].

The use of KMC within neonatal units is well documented and until recently has been reserved for stable preterm and LBW neonates. However, a recent release of new landmark guidelines by the WHO recommended KMC as the essential standard of care, starting immediately after birth for both well and sick, preterm and LBW infants. It further provides guidance for a global scale-up of KMC within health facilities and at home, starting right after birth for at least 8 h a day [33]. Implementing

KMC into neonatal transport offers the opportunity to overcome the severe limitations associated with incubator transfer in many developing countries.

Previous studies in higher-income countries on neonatal transport using skin-to-skin care/KMC reported it to be safe, cost-effective and a low-stress alternative to incubator during ground ambulance transport with no recorded adverse events [21, 34]. Inter and intra-hospital transport studies from the Philippines using KMC have reported no significant differences in the heart rate, respiratory rate, temperature, oxygen saturation, and blood glucose levels among preterm neonates [20]. with one study reporting a 93.7% reduction in risk of hypothermia [35].

To date, studies on KMC transport from Sub-Saharan Africa are lacking with no policy directive encouraging its implementation. Newborn transport in the region is mostly self-conducted with minimum care during the process. Exploring the safe use of KMC in the transfer of these neonates might help reduce the burden of neonatal mortality and morbidity in the region.

This study examined the feasibility of employing KMC in the transport of preterm and LBW neonates requiring specialized care in Cape Coast, Ghana.

Methods

This was a 2-arm nonrandomized controlled cluster study.

AIMS

1. To assess the feasibility of employing KMC in the transport of preterm and low-birth-weight neonates.
2. To assess the feasibility of conducting a future larger randomised controlled trial on the use of KMC in the transport of preterm and Low-Birth weight neonates in Ghana.
3. To compare the outcomes of neonates transported by KMC and current existing conventional methods of transport of preterm and Low-birth weight neonates.

Study setting

Country context

Ghana is a low- to middle-income country situated along the Gulf of Guinea in West Africa. It has a total population of approximately 31 million [9]. At the time of this study, sixteen administrative regions were implemented in the country. The country operates a universal national health insurance scheme (NHIS) that provides free health care to subscribed members. The scheme does not attempt to treat all the diseases suffered by insured members. However, common diseases such as malaria, upper respiratory tract infections, diarrheal diseases, and emergency medical care, such as road traffic accidents, are covered. Under the free NHIS, pregnant women and vulnerable populations, including elderly individuals (defined as individuals over 70) and children under 18, are exempt from the NHIS premium payment [36, 37]. The country has a national ambulance service that serves to provide prehospital emergency medical care as well as for transport. As of 2020, the country, with 275 constituencies and 8,847 healthcare facilities, had 362 functioning ambulances and 180 ambulance service stations [38]. Despite the sustained growth of ambulance services over the years, coverage has remained low, even in the main capital, Accra, which has an ambulance-to-population ratio of approximately 1:250,000—a ratio that is 5–10 times below expert-recommended ratios for lower-income countries [5, 39]. Public utilization also remains low, with the current norm to transport the injured or ill to the hospital being the use of private vehicles and taxis because of the belief that taxis are faster than ambulances [5]. Health service delivery in Ghana is decentralized with curative services delivered at the regional level by regional hospitals and district level, by district hospitals. At the subdistrict level, both preventive and curative services are provided by the health centres, as well as outreach services to the communities. Health centres are traditionally the first point of contact between the formal health delivery system and the patients and serve a population of approximately 20,000. They provide basic curative and preventive services, as well as reproductive health services. District hospitals are the first referral hospitals with about 50 to 60 beds and serve an average population of 100,000 to 200,000 people in a clearly defined geographical area. Regional hospitals form the secondary level of health care for their locations and Teaching hospitals are centres of excellence for the provision of complex health care [40].

Study area

The study was conducted in Cape Coast, which is the regional capital of the Central Region of Ghana. The Cape Coast metropolis is located 163 km west of the capital of Ghana, covers an estimated land area of 122 square kilometres and is considered the smallest metropolis in Ghana. It is located at longitude 1° 15'W and latitude 5°06'N. Cape Coast is the former capital city of Ghana (Gold Coast) and is considered one of the oldest districts in the country. Owing to the growing population, its status increased to metropolitan in 2007. It is bounded south by the Gulf of Guinea, east by the Abura Asebu Kwamankese District, west by Komenda Edina Eguafo Abrem Municipal, and north by the Twifo Hemang Lower Denkyira District. The population of the metropolis according to the 2021 population and housing census

was 189,925, with 92,790 males and 97,135 females. As a Metropolitan District, Cape Coast has health facilities at various levels of care, with the Cape Coast Teaching Hospital (CCTH) where this study was conducted being its tertiary referral centre.

CCTH is a 400-bed capacity hospital that serves as the teaching hospital of the University of Cape Coast, School of Medical Sciences (UCC-SMS), and as the main referral hospital for the central region and parts of western regions of Ghana. The hospital oversees approximately 2800 births per year. At the time of this research, the neonatal unit could provide continuous positive airway pressure (CPAP) ventilation support, oxygen, incubator care radiant warmers (although often shared), and phototherapy. KMC is routinely used in CCTH for the care of stable newborns who are being prepared for discharge, and nurses in the unit have regular in-service training on the KMC to improve practice.

Site selection

Four (4) primary care/maternity units with the highest referral/transfer to the neonatal unit of the CCTH were initially recruited following a review of the admission–discharge records over the past 2 years and a 2-month piloting of a designed proforma. Two of these sites were designated intervention sites, and the other two were designated control sites, with consideration given to the optimal balance for socioeconomic status, the size of the maternity unit, the ethnic mix, and the distance from the neonatal unit in CCTH. Two (2) additional maternity units were added to each arm of the study, 6 months into the study, to compensate for participant losses, particularly due to the institution of new policies directed by the Ministry of Health.

Participant recruitment

The intervention sites had posters displayed in the antenatal units, delivery suites and children's ward providing information about the study during the sensitization and training period. Potentially eligible participants were approached at their earliest antenatal appointment (using known risk factors for preterm delivery) or at an appropriately chosen time postnatally when the mother or the appropriate caregiver could give consent to the trained midwives/health care workers.

The decision to approach eligible women/families was made in liaison with the midwife/health care worker taking cognisance of the mother's health and mental state to minimize obtaining consent during a period of vulnerability.

The midwife/health care worker provided the mother/caregiver with comprehensive information about the study in the local language, and opportunities were given for the mother/caregiver to ask any questions about the study. Mothers/caregivers were reminded that they retained the right to not participate in the study and to withdraw consent or participate at any time without any form of impact on the care of themselves or their babies.

The midwives/health workers were trained in all the study procedures. A screening form was completed to record the number of mothers/caregivers approached about the study, eligibility, and at what stage women declined to participate.

All staff involved in the study and data collection were trained to collect and record physiologic parameters and outcome measures accurately. All staff involved reported and recorded information on adverse events during the transport process and before and after transport stabilization at the intervention sites.

The adverse events expected in this trial included the possibility of a neonate not tolerating the KMC resulting in difficulty breathing. However, previous studies on KMC in stable babies have reported no such adverse effects, but guidelines for dealing with such effects are part of health workers' training (Appendix 1).

Written consent was obtained from all participants who met the criteria for inclusion in the study.

Inclusion criteria

- Newborns < 2500 g and/or 28–37 weeks gestation at birth.
- Newborns less than 28 days old.
- Apgar score of at least 5 in the first and fifth minutes of life.
- Not requiring any ventilatory support, intravenous fluids, or vasopressors.
- Participants who provided informed consent were included in the study.
- Fathers or family members were willing to participate in situations where the mother was medically unwell for the transfer.

Exclusion criteria

- Apgar score of less than 5 at 10 min of age.
- Term neonates or neonates > 28 days of age.
- Preterm/LBW infants require prolonged resuscitation and oxygen therapy after 4 h of life.
- Newborns with major congenital malformations.
- Hypoxic ischaemic encephalopathy/prenatal asphyxia.
- Mothers with postnatal complications who were unable to give consent and had no dedicated family member to consent for inclusion in the study.

This list was not considered all-inclusive. If the midwife/health worker considered that the mother had other serious complications that would affect her suitability to participate in the transfer and that there was no guardian/relative to consent for the study, the midwife could use her discretion to exclude the mother from the study, noting on the recruitment form the reason for exclusion.

Mothers ($n=0$) withdrawn on clinical grounds by the study team could still complete follow-up if they were willing, with these data contributing to questions about the acceptability of the intervention.

Procedures

Stabilization

All neonates enrolled in the study had a period of initial stabilization before transfer, during which they received conventional care.

Conventional care (control group and KMC group)

Conventional care for neonates starts in the delivery room, where the nurse/midwife receives the neonate after delivery, quickly dries and wraps in a towel and provides the necessary resuscitation as prescribed by the Helping Babies Breathe algorithm. A physical examination to check for any anatomical anomalies was performed by the receiving health worker, and the babies were given vitamin K injections intramuscularly and tetracycline ophthalmic ointment. Vital signs (temperature, heart rate, respiratory rate, and oxygen saturation) were checked by the nurse, who fed either at the breast or expressed breastmilk via a cup or nasogastric tube. Participants recruited from control sites received conventional care, and their babies were transferred to CCTH via the current established mode of transfer.

Kangaroo mother care group (Intervention group)

Neonates at the intervention sites received the same initial stabilization and conventional care as neonates at the control sites. The participants (mother–baby pairs), who were identified by trained health workers at the intervention sites for transfer and who provided consent for participation in the study, were taught the appropriate procedure for KMC, and the babies were transferred to the special care baby unit (CCTH) with the intervention. The intervention sites assessed women's or caregivers' confidence and competence in using KMC, and any identified issues improved before the transfer.

Components of the study intervention

Intervention site midwives/health workers following recruitment into the study provided conventional care as described above. Initial observations (heart rate, respiratory rate, oxygen saturation and blood glucose) were obtained and recorded. Neonates with low blood sugar levels (< 2.6 mmol/L) were given milk, and their blood sugar levels were rechecked for normality before transfer.

The neonate wearing a hat and diaper would be transferred gently and placed upright against the caregiver's (mother, father, or relative) bare chest. The neonate's head was turned to one side in a slightly extended position with the hips flexed and abducted. The arms were flexed, and the neonate was secured via a fabric (KMC sling or the mother's usual cover cloth). The fabric was wrapped around the caregiver and infant in a sling-like fashion such that it covered the whole body of the infant securely. It was then tied in a firm knot on the side of the mother. An additional blanket or cloth was placed over the mother and infant during transport to provide warmth.

The participants were accompanied by a nurse or trained health worker if the facility was adequately staffed to provide such support; otherwise, the caregiver was instructed to place his/her hands to support the back and neck of the neonate and monitor respiration. Caregiver–neonate pairs were transported in the available mode of transport, and neonates were kept in the kangaroo position on the chest of the caregivers during the entire transport process.

Monitoring

Measurements of heart rate, respiratory rate, temperature, and oxygen saturation were performed before transfer with kangaroo care transport or usual transport and then checked every 30 min during transport if accompanied by a health worker and immediately upon arrival at the CCTH.

Heart rate and oxygen saturation were monitored by pulse oximetry, and the respiratory rate was obtained by counting the rate per minute.

Capillary blood glucose was obtained before transport and upon arrival at the CCTH.

Data analysis

For a feasibility study, the analyses utilized were descriptive statistics such as percentages, proportions, frequencies, means and standard deviations (SDs). Given our aims and that the numbers in this feasibility study were too small for reliable inferences, between-group comparisons of outcomes were not appropriate. This manuscript adhered to CONSORT reporting guidelines [41, 42].

Sample size

A formal power calculation hinged on detecting evidence for effectiveness was not performed because the study was a feasibility trial. Based on a recent review of admissions to the neonatal unit at CCTH [43], 60 participants

in the intervention arm were compared with the same number from the control sites. This was a pragmatic selection of sample size to allow us to identify evidence of feasibility, desirability, and recruitment rates and any problems with the intervention or research methods.

Outcome measures

Outcome measures were the survival and live discharge of preterm and low birthweight neonates. thermal stability (hypothermia), glucose control (hypoglycaemia), and oxygen saturation (hypoxia).

Feasibility

Feasibility will be assessed by collecting data on the following:

- Recruitment and adherence rates.
- Time required to recruit to target sample size.
- Cost involved in conducting the study.

Study period

The study period was from 1st August 2022 to 30th July 2023.

Results

Initially, 120 mothers were approached and consented to the study from 4 cluster sites. A new Ministry of Health policy implemented during the study resulted in the loss of participants and inadvertent prolongation of the study. Four new sites were subsequently recruited, with 2 new sites added to each arm. The numbers in each arm and the reasons are summarized in Fig. 1.

A total of seventy-seven participants (mother-baby pairs) recruited into the study were included in the final analysis: thirty-four in the KMC arm and forty-three in the conventional arm.

For both the conventional and KMC arms of the study, we aimed to recruit 60 mother–baby pairs each. The age and sex distributions of those recruited in both arms were similar, although there were marginally more males than females. In total, 60 women in each group were

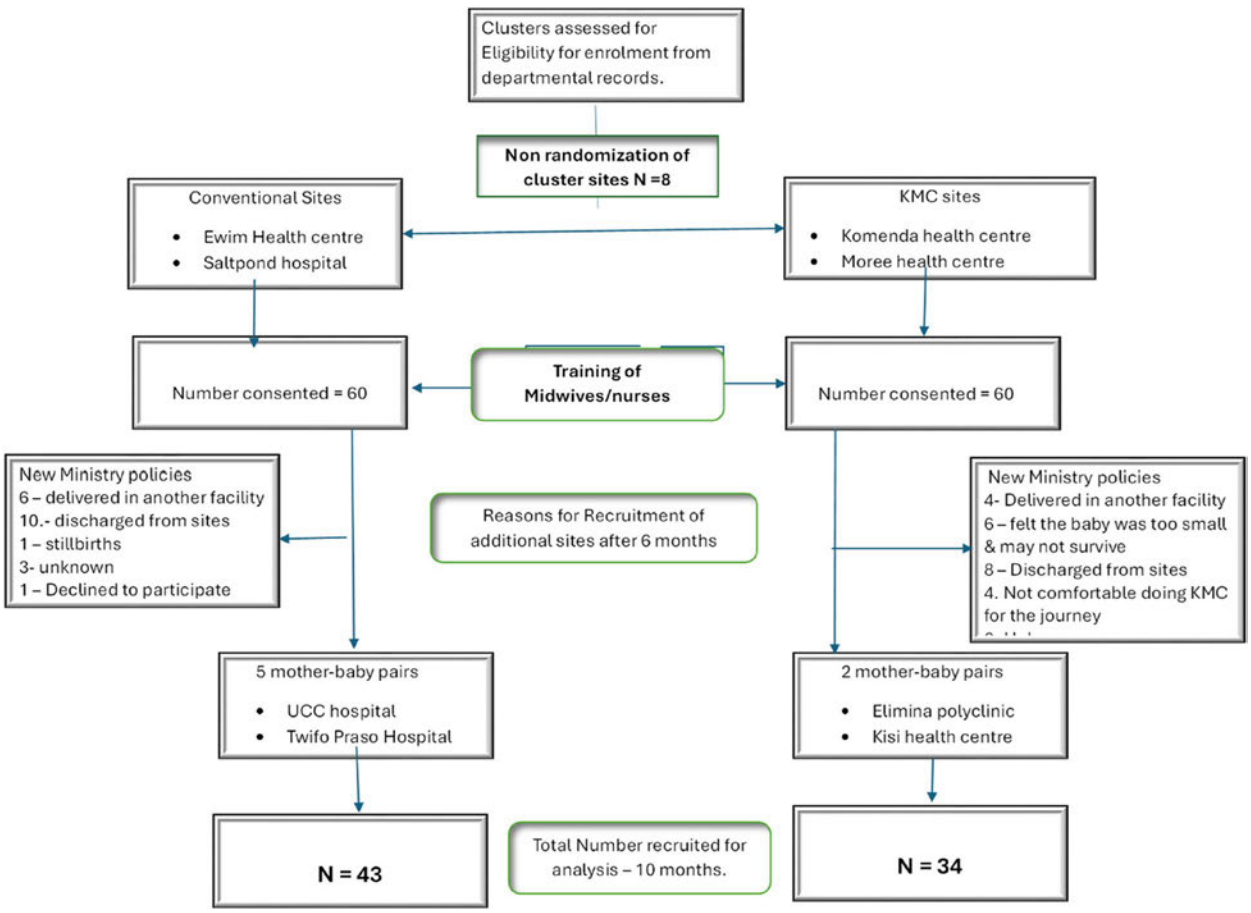

Fig. 1 Flowchart of the participant recruitment and randomization strategy

approached and consented to the study. However, after 6 months, 21 participants in the conventional arm and 28 in the KMC were lost for the reasons stated in Fig. 2. This necessitated the addition of 4 new sites, and recruitment of 7 additional mother baby pairs. Overall, 77 out of the 130 eligible mothers who consented eventually participated in the study, resulting in a yield of 59%. The nature of the study meant that following the transfer, no further interventions were required other than a follow-up to discharge and therefore an attrition of zero.

Background characteristics of the participating mothers (Table 1)

Most of the participant mothers were aged 20–32 years, with a median age of 24.4 years. In terms of marital status, 37.7% were single, 16.9% were cohabiting, and 45.5% were married. In terms of education, 22.1% had primary education, 45.5% had junior secondary school (JSS) education, and 16.9% had senior secondary school (SSS) education. The majority (42.6%) were unemployed, followed by skilled/manual workers (20.8%) and then those in sales and services (19.5%).

Comparison of characteristics between KMC-transport and conventional- care transport groups (Table 2)

Thirty-five (45.5%) of the babies were female, with 42 (54.5%) being male. The mode of delivery was mostly spontaneous vaginal delivery (92.3%), with equal numbers of babies who were resuscitated and not resuscitated. The gestational age of recruited neonates ranged from less than 28 weeks to 37 weeks with the majority between 28 and 32 weeks. The majority 58.4% of the transported neonates weighed less than 1.5 kg with 41.6% being above 1.6 kg.

Transport modalities and neonatal outcomes (Table 3)

Forty-three neonates were transported by existing conventional methods, with thirty-four being transported by KMC. Most of the babies were transported by taxis or private cars (60%), and 37% were transported by ambulances. The overall mortality rate was 20.8%, with high

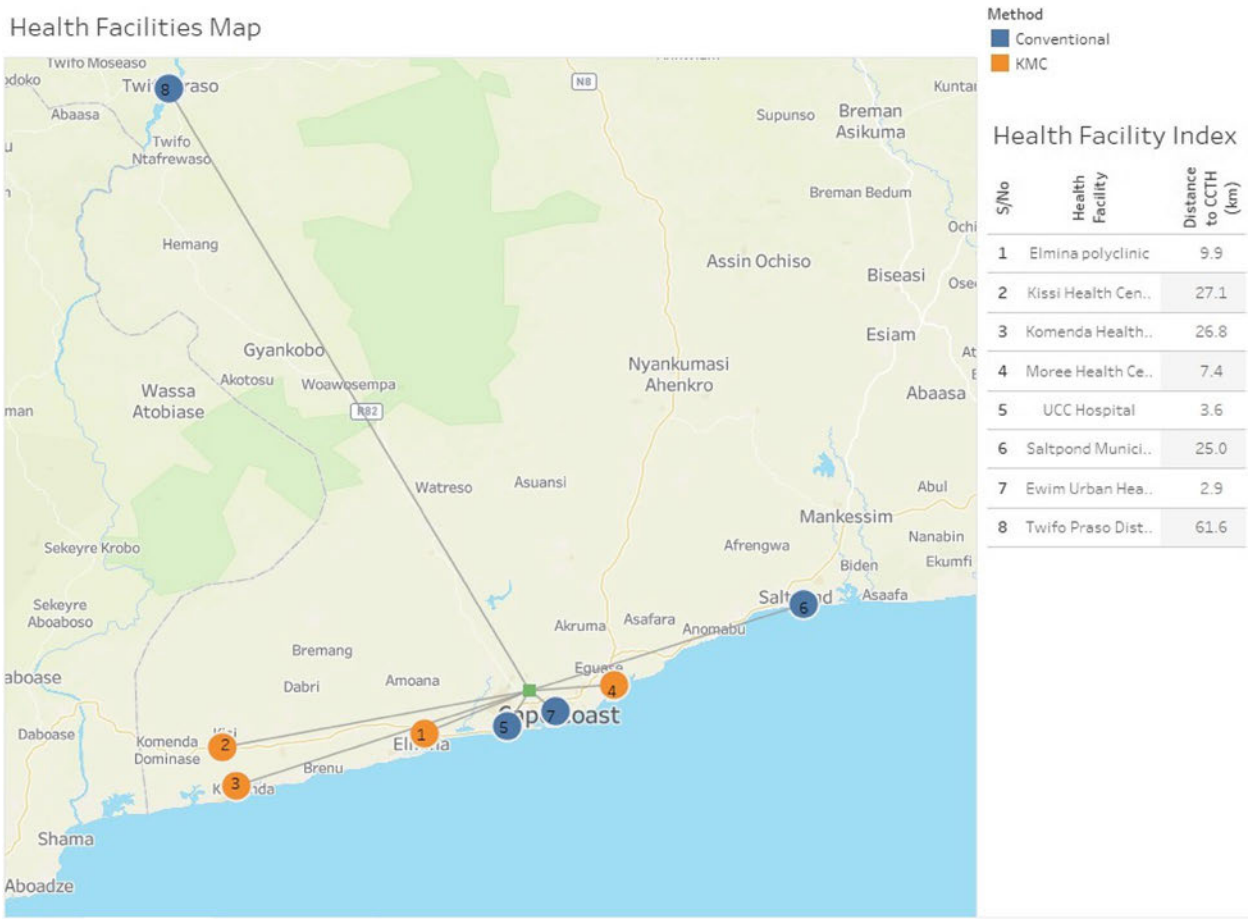

Fig. 2 Map showing the distribution of cluster sites

Table 1 Background characteristics of the participant mothers

Variable	Conventional	KMC	(Number (%)
Age in years(m ± sd)	25 ± 5.66	27.23 ± 7.58	Total
Marital status			
Cohabiting	10(13.0)	3(3.9)	13(16.9)
Married	19(24.7)	16(20.8)	35(45.5)
Single	14(18.2)	15(19.5)	29(37.7)
Education			
None	2(2.6)	1(1.3)	3(3.9)
Primary	11(14.3)	6(7.8)	17(22.1)
Jss	20(26.0)	15(19.5)	35(45.5)
Sss	6(7.8)	7(9.1)	13((16.9)
Tertiary	4(5.2)	5(6.5)	9(11.7)
Occupation			
Farming	1(1.3)	1(1.3)	2(2.6)
Professional/managerial	3(3.9)	3(3.9)	6(7.8)
Sales & services	8(10.4)	7(9.1)	15(19.5)
Skilled/manual	6(7.8)	10(13.0)	16(20.8)
Student	1(1.3)	2(2.6)	3(3.9)
Unemployed	24(31.2)	9(11.7)	33(42.6)
Unskilled/manual	0(0.0)	2(2.6)	2(2.6)
Household fuel			
Charcoal	23(29.9)	14(18.2)	37(48.1)
Firewood	3(3.9)	2(2.6)	5(6.5)
LPG/biogas	17(22.1)	18(23.4)	35(45.5)

Table 2 Delivery characteristics of neonates

Variable	Conventional	KMC	Discharged	Died
Normal Vaginal Delivery	41	30		
Number resuscitated	19	20		
Gender				
Female	20	15	30	5
Male	23	19	31	11
Gestational age				
< 28 weeks	2	5	4	3
28–32 wks	30	21	43	8
33–34 weeks	8	6	10	4
35–37 wks	3	2	4	1
Attendant at Delivery				
Midwife	36	30	51	15
Doctor	1	3	3	1
TBA	5	1	6	0
None	1	0	1	0
Birth weight(kg)				
< 1	6	4	4	6
1–1.5	22	13	30	5
1.6–2.5	15	17	27	5

mortality rates of 43 (11)−25.5% in the conventional group compared with 34 (5)−14.7% in the KMC group. No deterioration or untoward events were recorded for any of the babies transported by the KMC. There was no difference in blood glucose or oxygen saturation on arrival between the two arms, but marginally better temperatures were observed for the KMC group (Table 3).

Cost of KMC-transport (Table 4)

Exchange rate US$/GHS (1US$ = 14.5 GHS)

The cost involved in the process included the cost of a three-day training course for the midwives and nurses before the start of data recruitment, supervisory sessions during the study period and the cost of mobile telephone call credits for the recruitment team. The KMC cloth was the normal cover cloth used by the mothers, and vital sign monitoring equipment was hospital-acquired. No payments were made to participating mothers. Aside from the telephone credit costs, the other costs were fixed or semifixed costs, which did not increase linearly with increasing patient numbers.

Discussion

This study sought to answer the question of the feasibility of employing KMC in neonatal transport in Ghana, a sub-Saharan African country. Neonatal transport from peripheral birthing centres to the few specialized centres in many Sub-Saharan African countries is poorly organized with many transported neonates arriving in suboptimal conditions [11]. Despite the implementation of KMC in many neonatal units in the region with promising outcomes for preterm and LBW neonates, there are no documented studies from the region on KMC transport as an alternative to the current practice of transporting newborns in the arms of caregivers.

Results of a descriptive study by Sontheimer et al., Germany [21], and an RCT by Renelyn et al. in the Philippines [20] Showed that stable preterm can be transported over short and long distances by KMC without compromising their physiological status. Our study confirms this finding. Neonates in the KMC transport group remained stable with no difference in blood glucose or oxygen saturation on arrival, but marginally better temperatures compared to the neonates in the conventional group.

In our study, all neonates in the KMC group arrived at CCTH secured in the KMC positions with no adverse events recorded indicating that it is possible for KMC to the employed in the transport of stable neonates. This is in line with previous studies by Hennequin et al. (2018) in Brussels [34], Sontheimer et al. in Germany [21] Johannes van den Berg et al. in Sweden [44] and Renelyn et al. in

Table 3 Transport modalities and outcomes between KMC-transport and convention-care transport groups

Variable	Conventional	KMC	Discharged	Died
Indication for Referral				
Facility Not Equipped	40	30	56	14
No Oxygen	1	0	0	1
Other	2	3	5	1
Mode of Transport				
Ambulance	14	13	21	6
Taxi	22	20	36	6
Private Car	5	1	4	2
Foot	2	0	0	2
Did Mother accompany?				
No	20	7	19	8
Yes	23	27	42	8
Temperature on arrival (m ± sd)	35.4 ± 1.1	36.33 ± 0.6	35.9 ± 0.9	35.5 ± 1.2
Blood glucose (m ± sd)	4.45 ± 3.6	4.30 ± 2.3	4.2 ± 2.2	5.4 ± 5.2
Length of stay (m ± sd)	12 ± 8.3	13.8 ± 10.6	14.7 ± 9.3	5.8 ± 5.6
Transfer Sites (Distance-km)				
1. Elmina Polyclinic (9.9)	x	1	1	0
2. Kissi Health Centre (27.1)	x	1	1	0
3. Komenda health centre (26.8)	x	19	16	3
4. Moree Health Centre (7.4)	x	13	11	2
5. UCC Hospital (3.6)	3	x	2	1
6. Saltpond municipal Hosp (25.0)	20	x	15	5
7. Ewim Health Centre (2.9)	18	x	14	4
8. Twifo Praso (61.6)	2	x	1	1

Table 4 Cost associated with KMC-Transport

Item	Cost (GHS)	$ (equivalent)
3-day training session @ 500 GHS per day	1500	103.4
Telephone credit per month. 100 GHS per site	1000	69
Honoraria to the recruiting team. 200 GHS per site per month	8000	551.7
Cost per patient	136	9.4

the Philippines [20]. Our study confirms that KMC transport is feasible in newborns weighing less than 1 kg in contrast to studies by Gerlie et al. [35] and Renelyn et al. [20] which had the neonates in the KMC group being less than 2.2 Kg but above 1 kg. The transfers in our study were all land transports over distances of 7.4 to 27.1 km for the KMC group using public transport (private cars and taxis). This is in line with the study by Gerlie et al. in the Philippines [35] and supports the feasibility of KMC transport in resource-constrained settings using available transport where ambulance transport is limited.

Limitations

KMC transport in this study was at a low cost but would ideally be comparable if studies on incubator transport from this study and the region were available for compatibility. The patient care and journey for transferred neonates in CCTH, even though was out of the scope of this study can have an impact on mortalities between the two groups and needs to be explored in a larger study. Furthermore, differences in travel distances and missing data on accurate travel times between the two groups were a potential source of bias which could directly affect the outcomes. However, none of the transfers had an accompanying nurse/midwife and ambulance transfers were performed with paramedics who did not perform any monitoring or provide care during the transfer. The observed differences could not have been attributable to differential care during the transport process.

The strength of our study is in its application of KMC practice in neonatal transport in Sub-Saharan Africa using available land transport(taxis and private cars) with babies arriving at the referral centre not worse off physiologically compared to the current practice of wrapping them in a cloth and carrying them in the caregivers' arms. The low cost of transport, improved temperatures on arrival and an increased number of mothers accompanying the KMC-transported neonates providing continuous care compared to conventional care provide further strength in the feasibility and practicality of employing KMC in the transport of preterm and LBW neonates to improve outcomes.

Potential impact of missing data on the study findings

Six consented participants in the KMC arm of the study declined to participate because of parental concerns that the newborns were too small to be successfully transferred with KMC. Parental concerns about the poor survival of preterm neonates constitute a widely held local belief that often results in increased anxiety and delayed emotional attachment with preterm newborns. This local belief is deeply rooted in the rather stark neonatal mortality rates in Ghana, a situation that has continued to improve in the last two decades. These neonates were transferred to the CCTH by conventional means, 4 of whom were successfully discharged home and 2 of whom died. Adjusting for this lost group increased the total number of participants in the KMC from 34 to 40 compared with 43 in the conventional arm. The overall mortality in the KMC arm was adjusted from 14.7 to 17.5%, compared to 25.5% in the conventional group.

Conclusion

KMC transport from studies in other regions has been shown to provide physiological stability and no evidence of harm in transported neonates. This feasibility study from Ghana, a Sub-Saharan African country provides strength to employing this low-cost intervention which has the potential to improve continuous parental care and satisfaction as well as outcomes in transported preterm and LBW in the Sub region. The recent WHO recommendation for KMC to be adopted as the essential standard of care starting immediately after birth for all babies born early (before 37 weeks of pregnancy) or LBW should further empower local studies on KMC transport through larger clinical trials. This will inform clinical guidelines and policy development, as well as a scale-up in the implementation of KMC in the neonatal units and KMC transport in the Subregion.

Recommendation

A pragmatic trial focusing on the coordinated transfer of preterm and LBW newborns from peripheral birth centres to tertiary centres via KMC is urgently needed to assess the impact of such a low-cost but effective intervention on neonatal mortality in Sub-Saharan Africa.

Abbreviations

KMC	Kangaroo Mother Care
SSA	Sub-Saharan Africa
LBW	Low birth weight
LMIC	Low-middle-Income countries

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12887-024-05340-7.

Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions

EO: Conceptualization, Methodology, Resources, Investigation, Data curation, Formal analysis, writing, original draft. F F: Conceptualization, methodology, data curation, formal analysis, review, editing and supervision. HK: Data collection, methodology, project administration. ED: Methodology, review, editing and supervision. HS: Conceptualization, Methodology, Formal Analysis, review & editing. Supervision.

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Data availability

The anonymised data collected are available as open data via the Open Science Framework repository: https://doi.org/10.17605/OSF.IO/P9HVK.

Declarations

Ethics approval and consent to participate

Ethical approval was received before starting any data collection from the Cape Coast Teaching Hospital Ethical Review Committee (CCTHERC) with approval number CCTHERC/EC/2021 (053) on 30th July 2021. All patients received treatment as per standard Institutional policies. We confirm that all methods were carried out per relevant guidelines and regulations. Informed consent for participation in the study was obtained from the parents and /or their legal guardians.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Publisher's Note

5.4 Addendum to address post-viva requirements

Following the viva voce examination, it was identified that additional context regarding household fuel was required. Furthermore, portions of the text in Figure 1 were truncated and therefore revision is recommended to improve readability.

Although the published work comprehensively evaluated the variables presented in Table 1: "Background characteristics of the participant mothers", it did not account for household fuel as a variable.

As noted during the thesis examination, this limitation may affect the overall generalisability of the findings in certain contexts. Exposure to household air pollution from solid fuels was prevalent, with 55% of mothers relying on charcoal or firewood—a known risk factor for adverse birth outcomes—compared to 45% who used clean fuels such as LPG or biogas. While the proportion of mothers using charcoal and firewood across the different cohorts was not analysed, future studies may incorporate this variable to refine the understanding of the relationship between household fuel use, preterm birth, and birth outcomes.

A revised version of Figure 1, "Flowchart of the participant recruitment and randomisation strategy," has been appended below. BMC *Pediatrics* has been contacted to request an amendment to this figure; however, as the article has been published in its final version, they are unable to make changes to the published content. The publisher has explained that articles published with BioMed Central are also disseminated to and displayed on multiple indexing websites, such as PubMed. They are unable to update the content held by these sites, as doing so would create data inconsistencies. Furthermore, making amendments would contravene their permanency policy, available at: https://www.biomedcentral.com/about/policies/permanency-of-articles

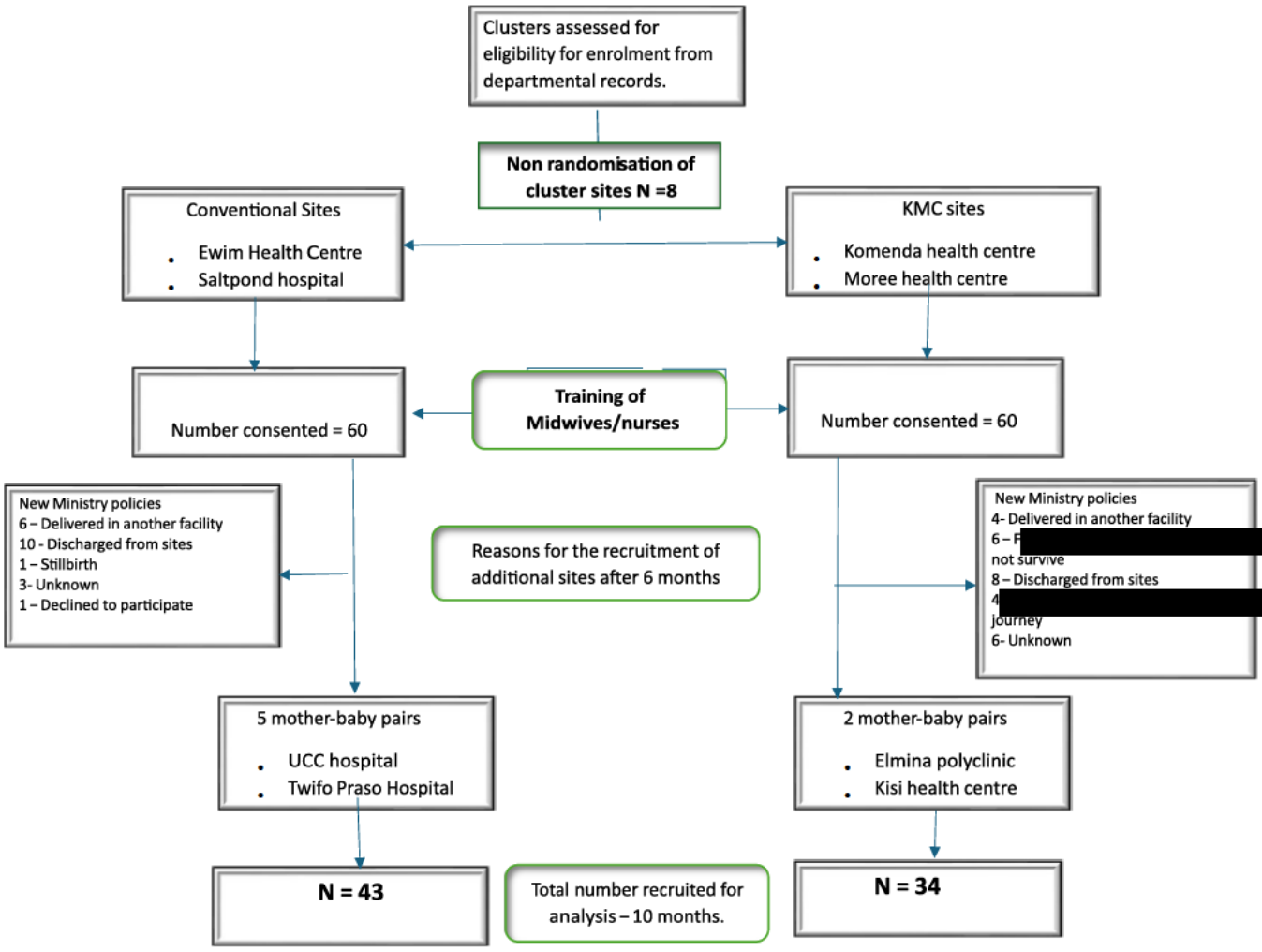

Figure 1: Flowchart of the participant recruitment and randomisation strategy

5.4.1 Exclusion of study participant from the conventional site

To satisfy the intention-to-treat principle—which underpins randomised trial analysis by ensuring balance between the study arms with respect to potential confounding factors and by preventing bias in estimates of the intervention effect—all participants who provided consent in this study were included in the final analysis. However, during the final analysis, one mother recruited late in the study at the UCC hospital, one of the additional conventional sites, was identified as not having met the full eligibility criteria. This was attributable to human error during the recruitment process. The participant gave birth to a

neonate at 37 weeks plus 3 days of gestation, weighing 2.85 kg; consequently, the baby was neither preterm nor met the criteria for low birth weight.

In the interest of integrity and transparency, the data from this participant were excluded from the final analysis, resulting in a total of 43 participants from the conventional sites, as indicated in Figure 1, rather than 44. Potential selection bias was not considered an issue, as decisions regarding the exclusion were not influenced by any trial sponsor or by conflicts of interest on the part of the investigators. Furthermore, given that this was a feasibility study not designed to detect statistically significant outcomes, the statistical power of the study—a major consideration in randomised trials—was deemed not to be affected by the exclusion of the ineligible participant who had been enrolled in error.

5.5 Summary and implications for the thesis

This study aimed to assess the feasibility of implementing KMC during neonatal transportation in Ghana, a country in Sub-Saharan Africa. The research compared outcomes for neonates transferred from peripheral birth centres to a tertiary care facility using conventional care (wrapped and carried in the caregiver's arms) versus those secured in the kangaroo position against the caregiver's chest, without modification of existing transportation modes. All neonates in the KMC group successfully arrived at the tertiary centre and were maintained in the KMC position. No adverse events were observed, indicating that KMC may be safely employed during the transportation of stable neonates. Although the results were not statistically significant, mortality rates were observed to be higher in the conventional care group compared to the KMC transport group. Additionally, mortality was higher among males than females in both groups, which is consistent with the existing literature (208).

Measurements of heart rate, respiratory rate, temperature, and oxygen saturation were recorded before transfer via kangaroo care or conventional care transport. Ideally, to allow comparison of these parameters between the two groups, they were to be monitored every 30 minutes during transit when a healthcare professional was present and immediately upon arrival at the CCTH by nursing staff. Heart rate and oxygen saturation were monitored by pulse oximetry, and the respiratory rate was obtained by counting the rate per minute.

In this study, axillary temperature was recorded using a Safety 1st 3-in-1 nursery thermometer (manufactured by Dorel Juvenile), a digital device specifically designed for neonatal and paediatric use, which is a standard thermometer employed in neonatal units across Ghana, where staff receive regular training and devices are calibrated monthly as discussed in the viva. The choice of axillary temperature measurement was based on its non-invasive nature, which provides a safer, more comfortable method for neonates. This technique circumvents the discomfort associated with rectal thermometry and diminishes the risk of potential injury (209). Nonetheless, it is important to acknowledge that although axillary temperature is widely used due to its convenience and safety, it does not accurately reflect core body temperature. Rectal temperature is often considered a more accurate indicator of core body temperature (210).

Due to the ongoing shortage of medical staff, none of the transfers included a nurse or midwife, and ambulance transfers were conducted by paramedics who neither monitored nor provided care during the transfer. Consequently, the effect of the KMC on these parameters during transit could not be compared. However, it was observed that neonates in the KMC group had slightly better temperatures upon arrival.

An additional challenge encountered during the course of the study was the extension of the timeline from six to ten months, prompted by a policy enacted by the Ministry of Health. This policy mandated the establishment of an emergency triage centre in Cape Coast to assist high-risk mothers in labour who require early referral for specialised care. This amendment impacted recruitment procedures, as pregnant women are now referred early for specialised treatment rather than delivering unsafely at peripheral facilities. Nonetheless, considering the unpredictability of preterm births, transportation using Kangaroo Mother Care remains imperative, as deliveries in peripheral regions cannot always be anticipated or scheduled for early referral.

The observations from this study have potential implications for both the thesis and the broader domain of neonatal care.

This is the first study from a Sub-Saharan African country, contributing to the limited evidence on the use of KMC during neonatal transportation. The only previous study in a LIMC setting was conducted in the Philippines (31). Both this study and the earlier one from the Philippines support the feasibility of KMC transport in resource-limited environments, using available transportation options when ambulance services are scarce.

Given the limited evidence on the use of KMC transport in the subregion, it is important to understand caregivers' and healthcare professionals' experiences with the intervention, as well as the factors that enable or challenge large-scale implementation. The following chapter presents the findings of the qualitative interviews conducted to explore this.

Chapter 6: Experiences of mothers and healthcare professionals of KMC transport of preterm and low birth weight infants

6.1 Introduction

This chapter presents Article C, the third and final component of this research programme, which is a qualitative exploration of the perspectives of mothers and healthcare professionals on KMC during transport from peripheral birth facilities to Cape Coast Teaching Hospital (CCTH), a central tertiary neonatal care unit. A summary of the rationale for and key findings of this study is presented, followed by a copy of the entire manuscript, which has been submitted to *BMC Pediatrics* for review. The chapter concludes by summarising the key findings of this qualitative element of the research programme and by discussing the contribution of this work to the thesis.

The systematic review presented within this thesis, together with the quantitative component of the research programme, has demonstrated that transporting preterm and LBW infants in the kangaroo position using available means of transport is feasible. The quantitative data analysis, however, does not contextualise these findings by considering the factors that may affect the transfer process from the perspectives of the participating mothers and healthcare professionals. However, these findings cannot be contextualised using quantitative methods. Qualitative research can provide the needed context by considering participants' experiences and understanding the perspectives that impact the acceptability of the intervention. The development of the interview schedules for mothers in the KMC cohort, healthcare professionals, and mothers in the conventional care cohort was informed and shaped by contributions from healthcare professionals at CCTH and peripheral birthing centres. Interviews were conducted simultaneously at the end of the transfers, which collected the quantitative data. This is an essential component of a

convergent parallel mixed-methods design. This qualitative component, therefore, aimed to explore the experiences and perspectives of both mothers and healthcare professionals regarding KMC transport as well as the barriers and enablers encountered during the transfer. This addressed the final aim of this research programme:

> **Explore the perspectives of mothers, carers, and healthcare professionals on the use of KMC for neonatal transport in Ghana.**

Data collection for the conventional care group was designed to explore (1) maternal satisfaction with the research protocol, (2) experiences with the prevailing neonatal transfer system in Cape Coast, and (3) concerns regarding neonatal care at the Cape Coast Teaching Hospital. The analysed findings provide critical insights for potential systemic improvements and are presented within this thesis.

6.2 Article C

The manuscript entitled "*Acceptability of Kangaroo Mother Care (KMC) in neonatal transport: A qualitative study on mothers' and healthcare professionals' perspectives on KMC transport in Ghana"* is reproduced here in the format that has been submitted for review.

6.3 Publication and impact

The manuscript describing this study is currently under review for publication in *BMC Pediatrics*. The supplementary data for this article are presented in Appendix H. These data include a COREQ checklist, interview schedules and coding themes for the cohort of mothers who practised KMC transport and for healthcare professionals. The interview schedule and theme codes for the mothers in the conventional care cohort are available in Appendix I. Although the latter were not analysed for the submitted manuscript, they were explored and discussed in this thesis following the viva voce examination.

Title Page

Acceptability of Kangaroo Mother Care (KMC) in neonatal transport: A qualitative study on mothers' and healthcare professionals' perspectives on KMC transport in Ghana

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Abstract

Background: In limited-resource settings, the lack of ambulances and transport incubators increases the risk of adverse outcomes in transported preterm and low birth weight neonates. The Kangaroo Mother Care (KMC) position during transport using available transport modes may be a cost-effective alternative. Mothers' and healthcare professionals' perspectives on the intervention are key to its successful implementation.

Methods: This qualitative study using semi-structured interviews was conducted at Cape Coast Teaching Hospital, Ghana. The study involved mothers and healthcare professionals who participated in a larger study evaluating the feasibility of KMC for transporting preterm and low birth weight infants from peripheral maternity units to the Cape Coast Teaching Hospital for specialist care. A thematic analysis was performed using an inductive approach. NVivo 12 was used to support the data analysis.

Results: A total of 16 respondents, including 10 mothers who used KMC during transfer and 6 healthcare professionals involved in KMC transfer, participated in the study. All the mothers interviewed expressed their willingness to participate in the study and to use KMC to transport their babies, even though they had not previously used it. The overriding reason for mothers becoming involved was the opportunity to help other mothers and to contribute to saving newborn lives. The mothers perceived KMC transport as empowering, comforting, and secure. Some challenges to KMC transport identified were maternal tiredness from long journeys, maternal anxiety about weather conditions, inability to see their baby's face, community resistance and stigmatisation, and a lack of maximum maternal comfort. Both mothers and healthcare professionals were overwhelmingly in favour of the intervention and agreed that enhanced education was vital to improving awareness and implementation.

Conclusion: Understanding the perspectives of mothers and healthcare professionals is vital for implementing cost-effective interventions to enhance neonatal outcomes, especially in resource-limited settings. The high acceptability of KMC transport in a Sub-Saharan African country provides relevant, context-specific evidence that supports expanding research into its large-scale implementation.

Trial registration: ISRCTN98748162. Retrospectively registered 02.09.2024.

Keywords

Kangaroo Mother Care, prematurity, low birth weight, neonatal transport, low- and middle-income countries, Sub-Saharan Africa

Acceptability of Kangaroo Mother Care (KMC) in neonatal transport: A qualitative study on mothers' and healthcare professionals' perspectives on KMC transport in Ghana

Background

The neonatal period (the first 28 days of life) is the most vulnerable period for child survival, with nearly half (47%) of all deaths in 2022 in children under 5 years of age occurring in the neonatal period (1). The neonatal mortality rate (NMR) is a critical health indicator that is crucial for assessing the quality of maternal and newborn care and for understanding the broader environment in which children are born (2). It is also a key Sustainable Development Goal (SDG)-specific target that aims for every country to reduce the NMR to 12 or fewer deaths per 1000 live births by 2030 (SDG target 3.2) (3).

Sub-Saharan Africa (SSA) had the highest NMR in the world, at 27 deaths per 1000 live births in 2022, followed by Central and South Asia, with an NMR of 21 deaths per 1000 live births (1). Preterm birth and its associated complications account for 40% of neonatal deaths, with preterm birth identified as the leading cause of death of children under five years of age worldwide and the most common cause of perinatal death (4). Small size at birth, due to preterm birth, small for gestational age (SGA), or both, are the biggest risk factors for more than 80% of neonatal deaths (5), with the majority of these deaths being preventable by a scale-up of cost-effective interventions, including KMC (6).

A recent World Health Organization (WHO) global position paper recommended KMC as the essential standard of care—starting immediately after birth—for all babies born before 37 weeks of gestation or weighing less than 2.5 kg at birth (7). Facility-based studies worldwide have demonstrated KMC's effectiveness in meeting neonates' needs for warmth, breastfeeding, protection against infection, stimulation, and early hospital discharge (8–10).

A large randomised-controlled trial across Ethiopia, Indonesia, and Mexico reported that, compared with conventional care, KMC was feasible, cost-effective, and more acceptable (11).

The increase in facility births to almost 80% globally (12) has not been reflected in a reduction in neonatal mortality, especially in SSA, where the absence of organised neonatal transport services and ambulances results in sick newborns being transported under suboptimal conditions from peripheral birthing centres to tertiary neonatal care centres. KMC can be used in any setting because it does not require specialised tools or technology, such as incubators, warmers, or cots, which are limited resources in low- and middle-income countries (LMICs), especially those in SSA and parts of Asia (13).

Since KMC was first implemented in Bogotá, Colombia, in 1978, other KMC practices have proliferated worldwide. It was implemented in African nations such as Ethiopia (11), Mozambique (14), South Africa (15), and Zimbabwe (16) in the 1980s and 1990s, primarily in teaching hospitals, with little further expansion to lower levels of care.

KMC is exemplified by the Every Newborn Action Plan (ENAP) (17) and has been implemented by many nations that have prioritised it, including Ghana, which adopted it in 2007 (18).

The benefits of KMC as an alternative, cost-effective method of transfer compared with conventional care, which is cost-intensive and highly technical (19,20) have been studied, with encouraging reports from a few advanced countries. KMC transport conferred comparable physiological stability to incubator transport in studies in Sweden and Belgium (21,22), and was reported as a safe, effective, and low-cost alternative in inter-facility neonatal transport, especially in limited-resource areas (23,24).

Effective implementation of KMC during neonatal transport would require concerted efforts to address context-specific, multifaceted challenges that complicate the safe transport of neonates, including cultural barriers and misconceptions about the practice (17,18,25,26). In facility-based studies, parental experiences of skin-to-skin care have been reported to be largely positive and beneficial, and an intervention that facilitates the growth of parental self-esteem and prepares parents to assume full responsibility for their children (27–29).

There is limited evidence concerning the perspectives of mothers and healthcare professionals on the use of KMC in neonatal transport. In a Swedish study on parents' experience of using the kangaroo position during ground ambulance transport, parents reported that it created a feeling of being important as a parent, as their participation during transport was appreciated, and holding their infant during the transport extended the time they were close to their infant (30).

Understanding these perspectives is crucial to successfully designing and implementing an outcome-based, culturally acceptable health intervention that employs KMC during neonatal transport in Ghana.

Methods

This qualitative study used semi-structured interviews to capture the perspectives of mothers and healthcare professionals regarding the use of KMC in the transport of preterm and LBW neonates.

Aims

To explore the acceptability of KMC as an intervention for neonatal transport by evaluating the perspectives of mothers and healthcare professionals on the practice.

The present study was part of a larger project that aimed to explore the feasibility of using KMC in the transfer of preterm and low birth weight infants in Cape Coast, Ghana (31).

Study setting

The study was executed in Cape Coast, the regional capital of Ghana's Central Region. The Central Region is situated 163 km west of Ghana's capital, Accra, and constitutes one of Ghana's 16 administrative regions. The population of the metropolis, according to the 2021 population and housing census, was 189,925 (32). As a metropolitan district, Cape Coast has health facilities at various levels of care, with the Cape Coast Teaching Hospital (CCTH), where this study was conducted, being its tertiary referral centre. CCTH is a 400-bed hospital that serves as the main referral hospital for the Central Region and parts of the Western Region of Ghana. KMC is routinely used in CCTH for the care of stable newborns being prepared for discharge, and nurses in the unit receive regular in-service training on KMC to improve their practice.

Participants and sampling

The study population comprised two main participant groups: mothers and healthcare professionals. For mothers, the sample comprised women who had used KMC in the transfer of their babies from selected peripheral birth centres to CCTH for specialist care in the larger feasibility study. For inclusion in the study, healthcare professionals—including nurses and midwives from the intervention sites or CCTH who participated in the initial

stabilisation or the transfer process—were approached to participate in the interviews. The healthcare professionals were nurses at CCTH who utilised KMC as part of their daily routine, and midwives from peripheral health centres who had received training on KMC and KMC transport before the commencement of the larger feasibility study. Owing to persistent staff shortages, none of the neonatal transfers to CCTH was accompanied by healthcare professionals. Mothers and healthcare professionals willing to participate were recruited through convenience sampling, with face-to-face approaches made during the consent process for the larger feasibility study. Convenience sampling was chosen owing to its straightforward implementation, time efficiency, and alignment with our constrained budget. Nonetheless, it is less optimal, as it may neglect important viewpoints from hard-to-reach populations and could lead to conclusions affected by the researcher's subjective bias and participants' motivations, thereby potentially introducing survey bias.

Data collection

Two interview guides—one for each target population—were designed by the research team, with input from nurses at CCTH and the peripheral maternity units. The interview guide for mothers (Appendix 1) was developed separately from that for healthcare professionals (Appendix 2)**.** The interview guides were semi-structured, with open-ended questions on the following topics: reasons for participating in the study; the practice of KMC; enablers and obstacles to KMC transport; personal experiences with KMC neonatal transport; and proposed solutions to improve the implementation of the practice. Semi-structured interviews were chosen for this study as they provided some control over the questions asked of the participants and allowed them flexibility to express views on methodology, initial care at stabilisation, and the transfer process concerning KMC. The

interview guides were developed in English and then translated into Fanti/Twi, the local language. Before finalisation, the interview guides underwent a pilot test on a sample of nurses and mothers to ensure understandability and acceptability to the target participants. The study did not include the data from the pilot interviews conducted during the initial data-gathering period, but minimal changes were made to the questions to be asked, especially the translation into Fanti/Twi to improve understanding. The interviews were conducted between August 2022 and April 2023 by the authors Hilda Konadu (HK) (a female neonatal nurse with an MSc in neonatal nursing and previous training in qualitative methods, and experience in conducting interviews) and Emmanuel Okai (EO) (a male paediatrician who attended a workshop on "how to conduct qualitative research" and "how to use NVivo software to analyse the data").

Mothers involved in the study were informed about the interviews when they consented to the larger feasibility study, and the interviews were conducted during their first or second visit to the neonatal unit at CCTH. The nurses were interviewed after the transfer of the neonates to CCTH, either on the day of transfer for nurses in peripheral units or one day after receiving the transferred babies at CCTH. All interviews were conducted face-to-face and lasted 20–40 minutes, with an average of 30 minutes. All the interviews were conducted in a quiet place outside the special care baby unit at CCTH, in consultation rooms in the paediatric outpatients' area, or at referral sites. All the interviews were digitally audio-recorded in English or Fanti, and the recordings were transcribed verbatim by Prince Arkoh (PA). No field notes were taken. The transcribed verbatim interviews were translated into English, reviewed, back-translated by HK and EO, and compared with the original interviews. No repeat interviews were carried out.

Data analysis

The resulting transcribed data were anonymised and managed using a Microsoft Excel sheet and NVivo 12 software to support coding. The transcripts were not returned to the participants for comment or correction. An inductive thematic analysis approach, as described by Braun and Clarke (33), was undertaken without trying to fit the data into a predefined coding structure or theoretical framework. An inductive method enabled the identification of themes from the data rather than the researchers' preconceptions. Three researchers, EO, PA, and Evans Ntim (EN), independently read the transcripts several times to familiarise themselves with the data, focusing on similarities and patterns. The research team then coded the dataset, with certain parts being coded jointly and others individually. The data were analysed iteratively and through discussion, and the researchers agreed on the themes and sub-themes emerging from the data. The sub-themes were reanalysed, focusing more deeply on existing patterns to see whether new perspectives could be found. Data saturation occurred when the researchers perceived that no new themes were emerging. Our study was reported according to the Consolidated Criteria for Reporting Qualitative Studies guidelines (Appendix 3).

Rigour and trustworthiness

Rigour during data collection was enhanced by recruiting participants with good variation within our inclusion criteria, standardising the interview questions while allowing for adaptation to the conversational flow, and using trained interviewers. During the analysis, interpretations were discussed between members of the research team. Potential acquiescence bias and interviewer bias by HK, as well as confirmation and analytic bias by

EO, who was aware of the quantitative study results, were properly acknowledged, and measures to mitigate these biases were implemented.

Ethical considerations

Ethical approval was obtained before commencing this study from (1) the Cape Coast Teaching Hospital Ethical Review Committee (CCTHERC) with approval number CCTHERC/EC/2021 (053), issued on 30 July 2021 and (2) the Sheffield Hallam University Research Ethics Committee (Ethic Review ID: ER46927191). All participants consented to the study.

Results

This qualitative study involved 16 participants, including 10 mothers who used KMC during transfer and 6 healthcare professionals involved in the KMC transfer. One of the mothers who was approached declined to participate due to her urgency to leave the unit and return home. The ages of the mothers interviewed ranged from 20 to 30 years. Eight of the mothers were married, living with their husbands, and two were cohabitating. In terms of education, three had primary education, three had junior secondary school (JSS) education, and four had senior secondary school (SSS) education. Four of the mothers were unemployed, with the rest being in sales and services. Regarding transport, three mothers travelled in private cars, and seven in taxis. The healthcare professionals interviewed included four nurses from CCTH and two midwives from peripheral centres. All of the nurses had more than two years of professional experience with KMC, and the midwives were

trained in KMC and had observed its practice. The demographic details of the babies transported by KMC are fully described in our previously published quantitative component of the larger feasibility study (31).

Three themes were identified from the data analysis: "Perceived benefits of KMC and study involvement", "KMC during transportation", and "Challenges and how to improve the process". Table 1 illustrates the themes and subthemes, and the participants' voices and quotations are presented in the results.

Themes	Subthemes
Perceived benefits of KMC and study involvement	• Beneficial to both mother and baby. • Helping other mothers and babies. • Trust and respect.
KMC during transportation	• Comforting and secure. • Empowerment from being able to provide protection and security. • Bonding during the journey.
Challenges and how to improve the process	• Maternal anxiety. • Comfort and safety during the journey. • Training and supportive healthcare staff.

Table 1: Themes and sub-themes within the analysis

Perceived benefits of KMC and study involvement

All the mothers interviewed expressed their willingness and excitement to become involved in the study and to use KMC for the transport of their babies, even though they had not previously undertaken KMC. Some expressed initial anxiety about participating in the intervention but felt supported and well-informed about the study, whereas others were curious to learn more about KMC and its benefits.

Beneficial to both the mother and baby: The idea of KMC was novel to most of the mothers. However, as they learned more about the intervention, they expressed favourable opinions

of KMC and enjoyed the concept. Several mothers were happy to use the intervention for transport because, after the explanation, they felt it would benefit both them and their babies.

"I thought the study could benefit me and my baby." (Mother 2, 28 years old)

"KMC for transporting newborns helps maintain the baby's temperature in situations where environmental factors, such as air conditioning in ambulances, could otherwise be harmful." (Healthcare professional 5, Midwife)

Helping other mothers and babies: The primary reason mothers became involved was the opportunity to help other mothers and save babies' lives.

"I wanted to help other mothers by sharing my experience." (Mother 1, 21 years old)

"I wanted to support research that could improve healthcare for babies." (Mother 5, 26 years old)

Trust and respect: A few mothers expressed their willingness to participate in the study after receiving care from the staff and after an explanation of the study. Being considered important players in the care of their newborns made some of the mothers not only trust the team but also feel important and respected.

"I felt supported, knowing that people cared about my experience." (Mother 5, 26 years old)

KMC during transportation

Mothers who consented to participate in the study were informed at the outset of the study's aim: to have their babies transferred to CCTH in the KMC position, without prearranged transport. Healthcare professionals facilitated transport by liaising with the drivers and ensuring their on-time arrival, but the parents made the payments. Parents were

free to choose their mode of transport, and the research team supported them in planning and facilitating transfer to CCTH.

Comforting and Secure: Mothers found the transport process comfortable, especially for the babies. Some mothers commented on the feeling of security that KMC provides for their babies.

"I felt that KMC kept my baby calm and comfortable throughout the journey." (Mother 2, 28 years old)

"KMC saves the lives of babies during transportation by providing better protection than simply wrapping them, which exposes them to harmful atmospheric conditions." (Healthcare professional 1, Nurse)

Empowerment from being able to provide protection and security: KMC transport was perceived by the mothers as empowering. They were inspired by witnessing their infants gain from the care, and the mother–newborn relationship was reinforced. The security they felt they were providing for their babies during the journey helped the mothers gain confidence and become advocates for this care approach.

"I felt KMC was a good way to protect my baby while moving around." (Mother 5, 26 years old)

"The challenge of not having ambulances has been overcome with KMC transport as the mothers are happy to be in the commercial vehicles with their babies close to them." (Healthcare professional 5, Midwife)

Bonding during the journey: Bonding was facilitated by performing KMC during transport. The mothers acknowledged their satisfaction with their babies during transport and highlighted how KMC helped them and their children.

"I felt more connected to my baby by using KMC while travelling." (Mother 9, 27 years old)

"The mothers have been keen to engage in KMC transport and have been happy with how it keeps their babies close during the transfer." (Healthcare professional 3, Nurse)

Challenges and how to improve the process

The results also revealed some challenges with KMC transport using available modes of transport rather than purpose-designed ambulances. Just as mothers were willing to participate in the study because they wanted what was best for other mothers and their babies, they offered solutions to improve the intervention that would make both mothers and babies more comfortable and safer.

Maternal anxiety: While some of the mothers' concerns could be attributed to a lack of familiarity with and experience with using KMC, others' concerns emanated from the maternal need for reassurance during the transport process.

"I worried about my baby's safety while trying to balance them in KMC." (Mother 3, 30 years old)

"Mothers often feel uncomfortable or hesitant about performing KMC, even after being informed of its benefits, so it requires extra effort from healthcare providers to convince them." (Healthcare professional 2, Nurse)

Comfort and safety during the journey: All the mothers interviewed confirmed that they would use KMC for transport again if allowed, even though certain aspects of the journey were uncomfortable. Some nurses mentioned issues with stigmatisation in using public transport in the absence of ambulances.

"I found it tiring to hold my baby, especially during a longer journey." (Mother 6, 29 years old)

"Performing KMC in public transport can lead to stigmatisation, as people may stare or react negatively. To address these issues, having specialised transport specifically for cases requiring KMC would be beneficial, ensuring smoother and more dignified transfers to healthcare facilities." (Healthcare professional 3, Nurse)

Training and supportive healthcare staff: Various situations that result in suboptimal experiences with the process for mothers could be attributed to limited education on KMC. The provision of appropriately prepared KMC materials, purpose-made transport, communication about what to expect during the journey, and feedback from mothers who have engaged in the KMC transport were among the solutions mothers offered. Improving maternal confidence in monitoring their babies during the journey through education, as well as support and regular training for medical staff, emerged as ways to improve the process.

"Provide more training for mothers on how to use KMC properly." (Mother 1, 21 years old)

"To support nurses in using KMC for transport, it is important to address the gap between awareness and practical knowledge. Many nurses have heard of KMC but lack hands-on experience. Providing educational materials, such as flyers or pamphlets, that demonstrate

the procedure and outline its benefits can be very helpful." (Healthcare professional 4, Midwife)

Discussion

The objective of this study was to investigate the acceptability of Kangaroo Mother Care as an intervention for neonatal transport by exploring the perspectives of both mothers and healthcare professionals concerning the intervention. This qualitative study offers new insights into the perspectives and acceptability of KMC transport within a resource-limited setting in Sub-Saharan Africa. The results show that mothers accept KMC as a safe and cost-effective intervention during the transport of their babies for specialised care. The care and well-being of their neonates, as well as the opportunity to contribute new knowledge that would help other families in a similar situation, were the overriding reasons many mothers participated in the study. The KMC position during transport felt natural to several of the participants. Parents appreciated the opportunity to share their perspectives on their infant care plans, recognised the significance of bonding with their child during KMC transport, and believed that their efforts provided a nurturing environment. This recognition reinforced their sense of importance and self-worth while enhancing parents' confidence in their caregiving abilities. According to the mothers in this study, the infant was comfortable during the transfer because of the proximity and the child’s steady, secure position on their chest. The parents believed that as their infants were securely fastened in the sling and they could encircle the baby with their arms, they were providing protection from external movements in the selected vehicle. These positive parental experiences align with studies on parental experiences with kangaroo positions during neonatal ground ambulance transport by Van

den Berg *et al.* (21), Sontheimer *et al.* (34), and Lundqvist *et al.* (30) in Sweden and Germany. The study by Sontheimer *et al.* (34) found that parents were content and comfortable during the transfer of their infants, findings similar to ours.

Similarly, the positive experiences of "uninterrupted closeness", "feeling important as a parent", and "promoting security and a positive environment for the baby" reported by parents in the Lundqvist *et al.* study (30), even though it was from a higher-income setting, bear similarities to the views expressed by the mothers in our study.

KMC has continued to scale up as a care method in many neonatal units in Ghana since its introduction in 2007 (18). It is used effectively in CCTH for the care of preterm and LBW infants. The mothers in our study were not familiar with the practice but were sensitised through posters and trained in its use before their inclusion in the study. The decision on which mode of transport to use was left to the participants' discretion, but the research team provided facilitation, which was made clear at recruitment. Despite relying on private taxis and other vehicles because of a shortage of ambulances, as is currently the case in Ghana, most parents in our study reported feeling safe, and the kangaroo position during transport created a sense of security, warmth, and comfort for their babies.

To the best of our knowledge, this is the first study from Sub-Saharan Africa to focus on parents' detailed experiences of the kangaroo position during transport with private vehicles in the absence of dedicated ambulances. A randomised-controlled trial in the Philippines in 2021, by Ignacio *et al.* (37), comparing the physiological outcomes of neonates weighing less than 2,200 g transported by either KMC or a transport incubator within a tertiary care facility, showed that KMC transport is equally effective as transport incubator transport. The sole additional study regarding inter-facility neonatal transfers employing KMC in resource-

constrained settings without transport incubators or ambulances was conducted by Zamora *et al.* in the Philippines (23). This study primarily concentrated on physiological outcomes and did not examine the acceptability of the intervention among parents or healthcare personnel. The study did not compare the intervention to the standard of care, but rather to usual care in resource-limited settings. Transport incubators and ambulances were not immediately available for use. KMC transport markedly reduced hypothermia (97%) compared with routine practice, in which 50% of these infants developed hypothermia despite swaddling. The study concluded that KMC transport was significantly better than the usual mode of transport.

In our study, parents' confidence as they transitioned into their new role as parents was enhanced, as they were enabled to provide security, warmth, and comfort for their babies during transfer. Unlike our study, which did not have a health worker accompanying the mothers, the parents in the Swedish study reported that their role as parents was validated, as the accompanying nurse took their understanding of their infant's needs and behaviour seriously. Finding strategies to help parents adjust to their new roles as parents is crucial because an altered parental role is known to cause stress (35,36).

The success or failure of the effective implementation of KMC transport depends heavily on whether healthcare professionals responsible for ensuring its operations are educated and aware of the method. In our study, both mothers and healthcare professionals shared similar perspectives on ways to improve KMC transfer. They emphasised the need for education and awareness. There is a need to help mothers become familiar with the method so that KMC is incorporated into the transfer options they have. Antenatal education, especially for those at risk of preterm and LBW births, may be a good option. As some nurses mentioned,

community and family resistance to the process can be a challenge; therefore, education should target not only mothers but also, importantly, other family members, especially fathers.

The positive awareness among nurses in our study highlights a conducive environment for implementing KMC transport. However, the few potential problems envisaged with the use of KMC for transport were maternal tiredness on long journeys, maternal anxiety about weather conditions, inability to see their baby's face, and resistance from family members. They were considered surmountable from the healthcare professionals' perspective, but are worth noting and communicating to mothers to ensure they are fully prepared to use the KMC. Liaising with local transport unions to train dedicated drivers on the purposes and benefits of KMC, and to have their vehicles modified to make them more comfortable for journeys, with the support of the regional health directorate, would be a pragmatic solution to some of the challenges mentioned by mothers and healthcare professionals. Community sensitisation programmes to educate the public about the benefits of KMC transport and clarify any misconceptions would help address stigmatisation and enhance the scale-up of the intervention.

The results of our larger study on the feasibility of KMC transport in Ghana revealed potential positive outcomes, such as improved temperatures on the arrival of transported neonates and reduced mortality (31). This, along with its acceptability to mothers and healthcare professionals, underscores the importance of further scaling up and evaluating this intervention.

Limitations and strengths of the study

We acknowledge the potential for social desirability bias among mothers during the interviews. To mitigate this bias, the interviews were conducted in quiet rooms outside the neonatal unit by research staff only, and data confidentiality was maintained after the interviews were completed. Issues related to acquiescence bias, interviewer bias, and researcher bias that could affect data collection and analysis were properly acknowledged and addressed.

Additionally, there is a lack of perspectives from healthcare professionals on transport conditions and monitoring during transport. This could be addressed in a larger-scale study with dedicated healthcare professionals assigned to accompany mothers during the transfer.

The strength of our study lies in its innovative application of KMC in neonatal transport using available modes of transport in Sub-Saharan Africa. It offers a combination of perspectives from mothers and healthcare professionals on KMC transport and how to enhance the process. The interviews were conducted in multiple languages to ensure that they were accessible to all the women from the area who participated. Most of the mothers invited participated, thereby eliminating self-selection bias, which occurs when only individuals with positive perceptions are recruited. Importantly, this study contributes to the scarce existing evidence regarding perceptions of KMC transport in LMICs.

Implications for clinical practice and future research

The results of our study show that KMC transport is largely acceptable; therefore, wider implementation and evaluation are needed. This study identified several measures that

could increase the uptake of KMC transport. These include addressing the challenges identified in this study and enhancing the education of health professionals and mothers.

1. The mothers' acceptance of KMC transport indicates that the intervention could be introduced earlier, possibly at antenatal clinics in peripheral maternity units, to raise awareness and provide a practical alternative method of transfer for families, particularly those at risk of preterm or SGA/LBW birth.
2. The empowerment experienced by mothers can be harnessed to enhance knowledge regarding KMC transport within the community and to provide opportunities for them to serve as role models.
3. Peripheral maternity units can be empowered to collaborate with local transportation organisations to identify and educate drivers on providing safe, comfortable, and prompt transport for newborns utilising KMC.
4. Regular and enhanced training of healthcare professionals on KMC transport can boost KMC utilisation across different neonatal units in Ghana.

Conclusion

The dedication of mothers participating in research aimed at assisting others in comparable circumstances, coupled with the empowerment they experience through KMC during transportation, facilitates high acceptance of the intervention in a resource-limited setting. This acceptance, alongside improved education for mothers, family members, community participants, and healthcare professionals, will be instrumental in implementing, assessing, and expanding KMC transport within a broader study in Ghana.

List of abbreviations

KMC	Kangaroo Mother Care
LBW	Low birth weight
LMIC	Low- and middle-income countries
SGA	Small for gestational age
SSA	Sub-Saharan Africa
CCTH	Cape Coast Teaching Hospital

Declarations

Ethics approval and consent to participate

Ethical approval was obtained before commencing this study from (1) the Cape Coast Teaching Hospital Ethical Review Committee (CCTHERC) with approval number CCTHERC/EC/2021 (053), issued on 30 July 2021 and (2) the Sheffield Hallam University Research Ethics Committee (Ethic Review ID: ER46927191). We confirm that all methods were carried out in accordance with the relevant guidelines and regulations. Informed consent for participation in the study was obtained from parents and healthcare professionals.

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and/or analysed during the current study are available in the Open Science Framework repository, https://doi.org/10.17605/OSF.IO/NXAZQ

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

All persons who meet the authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this manuscript has not been published in any other journal. All the authors have read and approved the submitted manuscript.

Emmanuel Okai: Conceptualisation, methodology, resources, investigation, data curation, formal analysis, and writing of the original draft. **Frankie Fair:** Conceptualisation, methodology, data curation, formal analysis, review, editing, and supervision. **Hilda Danquah Konadu:** Data collection, methodology, and project administration. **Prince Arkoh:** Methodology, formal analysis, interview transcription, review and editing. **Evans Ntim**: formal analysis, review and editing. **Eugene Darteh:** Methodology, review, editing, and supervision. **Hora Soltani:** Conceptualisation, methodology, formal analysis, review, editing, and supervision.

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6.4 Maternal perspectives from the conventional care cohort

Semi-structured interviews were conducted with four mothers from the conventional care cohort, aged 24–30. Supplementary data for the interview schedule and theme codes for the conventional care cohort are available in Appendix I. All participants reported satisfaction with the study process, specifically highlighting the clarity of the informed consent procedure and the adequate time afforded to them to consider their participation. Their primary motivation for involvement was altruistic, similar to the KMC cohort, as they uniformly expressed a belief that the study would yield insights to improve future care for infants and support for mothers in similar situations. Regarding neonatal transfer, none of the mothers used an ambulance and transfers were equally facilitated by taxis and private cars. Their perspectives on the transfer process and neonatal care were analysed and grouped into two primary themes.

Theme 1: Systemic challenges in neonatal transfer

Mothers identified significant systemic barriers, including financial constraints in securing ambulance services, frequent ambulance unavailability, and poor road conditions. A paramount concern for all participants was the absence of accompanying healthcare professionals during transfer, which was reported to markedly increase maternal anxiety regarding infant well-being.

"If a nurse is available, maybe they can come with us because the baby is small and we were all worried about him during the journey." (Mother 4, 30 years old)

To improve this experience, mothers unanimously recommended ensuring consistent ambulance availability and providing professional medical accompaniment during their journeys.

Theme 2: Opportunities for enhancing inpatient neonatal care

While mothers expressed overall satisfaction with the clinical care their babies received, they emphasised the need for improved communication from both doctors and nurses. They indicated that more transparent and consistent information about their infant's condition and treatment would help alleviate parental anxiety.

"We found the staff's reception, especially from 'Auntie Corny' (staff member's name), to be warm and comforting. We were satisfied with the service, but I feel the nurses have to talk to us more because we worry a lot, especially because the baby is small." (Mother 3, 27 years old)

Furthermore, one mother noted infrastructure limitations, describing the neonatal unit as somewhat small and prone to overheating.

These findings on suboptimal transport systems and communication gaps align with our previously published research on inadequate neonatal transport in Sub-Saharan Africa (145). The admission of an infant to the neonatal unit is a profoundly stressful event for parents. In this context, the role of nursing communication is critical; it must extend beyond relaying clinical information to include reassuring and empathising with parents, as well as educating and guiding them in caring for their infants. The perspectives gathered from this cohort underscore the interrelated needs for robust logistical support and compassionate, proactive communication to improve the overall parental experience.

6.5 Summary and implications for the thesis

This chapter presented the qualitative phase of the research programme. It explored the experiences and perspectives of mothers and healthcare professionals regarding KMC transport in Cape Coast, including the challenges encountered during the transfer and mothers' perspectives on neonatal care at CCTH. It provided some solutions to the challenges, helping shape future large-scale research and implementation of the intervention. The results showed that mothers accepted KMC transport as a viable alternative to transporting their babies. The mothers perceived KMC transport as empowering, comforting, and secure. Notably, both mothers and healthcare professionals were mainly in favour of the intervention and agreed on enhanced education as key to improving awareness and implementation. This agreement demonstrates the unity and collaboration in the KMC transport process. The study identified some challenges that need to be addressed in future studies for the intervention to be effectively implemented. These included maternal tiredness on long journeys, maternal anxiety about weather conditions, not being able to see their baby's face, stigmatisation and community resistance, and lack of maximum maternal comfort, especially for long journeys. Mothers in the conventional care group suggested augmenting logistical support during neonatal transfers and adopting compassionate, proactive communication to enhance the overall parental experience of care for their neonates at CCTH.

The following chapters of this thesis integrate the findings of each of the three components that comprise this research programme and address the contribution of this thesis to the existing literature in the area. They also outline future research avenues arising from this thesis, highlighting the potential for further development and improvement in KMC

transport. The limitations and strengths of the research will be addressed, providing a comprehensive view of the research process and its outcomes.

Chapter 7: Integration of the research findings

7.1 Introduction

This thesis has presented a systematic review of the available evidence on neonatal practices in Sub-Saharan Africa, followed by a research programme consisting of three original research articles. This research programme employed a mixed-methods study with a convergent parallel design. A key characteristic of this research design is the integration of the research findings from the parts of the programme of work to construct overall themes. Therefore, this chapter completes the synthesis of the quantitative and qualitative data collection and analysis phases.

7.2. Integration of findings

As described in chapter 4, this thesis is grounded in a convergent parallel mixed-methods design. In this model, the weight can be assigned to either the quantitative or the qualitative aspect, or to both equally, and the merging of the two methods occurs at either the data analysis stage or the stage of interpreting the results of the two parts of the study. In this research programme, weight was assigned equally to both quantitative and qualitative phases, and the merger was achieved at the stage of interpretation of the results by contrasting the quantitative results and findings from the qualitative research to corroborate or cross-validate findings derived from the entire study (183).

The quantitative analysis demonstrated that all neonates secured in the KMC position during transport arrived at Cape Coast Teaching Hospital and remained securely positioned. Furthermore, no adverse events were recorded in this group, and these neonates potentially exhibited marginally higher temperatures upon arrival and lower mortality rates at discharge than those transported by conventional methods. However, these differences

were not statistically significant, consistent with the study's design as a feasibility study with a limited sample size; it was not powered to detect clinically significant differences in clinical outcomes.

These findings suggest that KMC transport not only potentially reinforces the documented physiological benefit of improved thermoregulation but also provides the critical advantage of avoiding separation of mother and neonate. As per the study aim, participants utilised existing transport modalities in Ghana, a context characterised by limited ambulance availability and the absence of dedicated neonatal transport teams.

The subsequent qualitative phase sought to contextualise the quantitative results by exploring the experiences of mothers and healthcare professionals during transport. The objective was to develop a nuanced understanding of the intervention to inform its future adaptation and scalability. The following section synthesises the findings from both phases into a series of overarching themes.

7.2.1 Clinical benefits of KMC transport

The first overarching theme identifies promising clinical trends from the non-randomised comparative data. Neonates transported via KMC demonstrated potentially improved thermoregulation and a decrease in mortality. Although these clinical outcomes did not reach statistical significance, they suggest a beneficial effect, justifying a large-scale trial to conclusively evaluate the efficacy of KMC transport in mitigating high neonatal mortality rates in LMICs.

7.2.2 Social and cultural context

The quantitative results confirmed that all the mothers in the KMC transport cohort, regardless of socioeconomic status, arrived at the referral facility with their neonates securely positioned. This finding must be contextualised by the pervasive lack of dedicated ambulances, with most transfers occurring via taxis or private vehicles, as is current practice.

The qualitative data elucidated this logistical challenge for both the KMC and conventional care cohorts. The KMC cohort reported that, despite financial constraints in securing transport in the absence of government ambulances, they valued the ability to maintain a physical bond with their infants during the journey. This synthesis indicates that systemic deficiencies in neonatal transport logistics can be alleviated by the fundamental parental obligation to prevent separation. Therefore, KMC transport is a viable and advantageous alternative in resource-limited settings.

Furthermore, the intervention demonstrated a strong alignment with sociocultural norms. The practice of securing an infant to the chest is not culturally proscribed; in fact, it is reinforced by local traditions. The common "open blouse" (or *kaba*) style of dress in Ghana facilitates skin-to-skin contact. This, combined with cultural postpartum confinement practices designed to enhance maternal–infant bonding, creates a receptive environment for both KMC and its extension to neonatal transport. The "open blouse" dressing style, referred to as "*kaba style",* combines a blouse—usually made from cotton fabric with traditional African prints such as Kente or Ankara—with a long skirt that often features slits. The blouse is tailored to fit snugly, comes in various cuts and necklines, and is styled open to display part of the undergarment beneath.

7.2.3 KMC as an empowerment intervention for parental roles

Zero separation, according to the Global Alliance for Newborn Care, is a family-centred approach to newborn care that advocates keeping babies with their parents, particularly mothers, regardless of health issues (211). The "Zero Separation Policy" would most likely benefit both the mother and the baby. Not only will it spare the baby from potentially risky NICU environments, but it will also free the mother from stress and allow her to bond with the baby at an initial stage. The quantitative analysis indicated that although maternal consent for KMC transport was high, a minority of participants perceived their neonate's small size as a challenge for the technique. Conversely, qualitative findings revealed that the primary maternal motivation for participation was an altruistic desire to contribute to an intervention that could assist other mothers and improve neonatal survival despite a lack of prior experience with KMC.

Furthermore, qualitative data characterised the KMC transport position as a naturally nurturing environment. Mothers reported that being physically present during transit, with their infant securely against their chest, fostered a significant sense of empowerment and facilitated the consolidation of their new parental roles.

7.2.4. Education

The qualitative findings identified consistent, comprehensive training for both healthcare professionals and mothers as a critical facilitator of the efficacy and widespread adoption of KMC transport. This need is substantiated by the quantitative data, which showed that some mothers were lost to recruitment due to perceptions of their neonate being too small or fragile—a belief underscoring a sociocultural barrier that can be mitigated through targeted maternal education.

Qualitative data further revealed that maternal anxiety, stemming from factors such as first-time experience, adverse weather conditions, or an inability to visually monitor the infant, presented additional challenges. Healthcare professionals corroborated this, identifying a significant gap between the theoretical awareness of KMC and practical, hands-on competency. Although KMC is a known concept in Ghana, a lack of practical experience among nurses compromises their confidence and efficiency in facilitating the technique.

To address these barriers, a multifaceted educational strategy is recommended. The development and dissemination of visual aids, such as instructional flyers and pamphlets demonstrating the procedure and its benefits—which proved effective in this study—are essential. Complementing this with regular in-service training sessions led by KMC experts would serve to update knowledge and enhance the practical skills of both nurses and mothers. This consolidated approach to education is crucial for empowering healthcare professionals to adequately support mothers, thereby optimising KMC transport and improving neonatal outcomes.

7.3 Summary

As set out earlier, the findings of this research programme have been synthesised, and four overarching themes, that is, clinical benefits of KMC transport, social and cultural context, KMC as an empowerment intervention for parental roles, and education, have been generated. The following chapter elaborates on these overarching findings and situates them within the broader research literature. It also entails identifying the main strengths and limitations of this research programme and making recommendations for future directions.

systematic review by Zengin *et al*. examined how KMC impacts the physiological parameters of premature infants in neonatal intensive care units. The review found that the KMC group experienced positive outcomes in terms of "temperature" ($z = 3.21$; $p = 0.000$) and "oxygen saturation" ($z = 2.49$; $p = 0.000$). However, there was inadequate evidence to conclude its effect on "heart rate" ($z = -0.60$; $p = 0.55$) and "respiratory rate" ($z = -1.45$; $p = 0.15$) (212).

Kangaroo care effectively raises the infant's body temperature by direct heat transfer through conduction (213) from the mother's skin to the infant's. The chest area near the heart typically shows a higher skin temperature due to increased blood circulation (214). A meta-analysis by Boundy *et al.* (24) in 2016, which reviewed 124 studies, concluded that KMC significantly elevated newborns' temperatures, corroborating Knobel-Dail's findings from 2014 (215). Furthermore, in 2000, Ludington-Hoe *et al.* (125) reported that KMC assists infants in maintaining a temperature more suitable for their age and weight than standard incubator settings.

Eksirinimit *et al.* conducted a quasi-experimental study on premature infants, investigating temperature changes during each period after KMC. They assigned 32 infants to the KMC group and 32 to the control group (216). They applied KMC to mothers and infants for 1 hour per day over 3 consecutive days. The control group received no intervention beyond usual care. The infants' temperatures were measured before KMC, immediately after KMC, and at 30 and 60 minutes after KMC. They found that the average infant temperature in the KMC group during days 1 to 3 was significantly different ($p < 0.001$), indicating variation in average temperature across the four time points. The average temperature recorded at three time points post-KMC was notably higher than that of the control group on days 1–3

($p < 0.01$). They concluded that KMC is practical, safe, cost-effective, and suitable for both mothers and premature infants to raise temperature, whether in hospitals or at home (216).

A Cochrane review of 20 trials involving 2,969 infants assessed the evidence supporting KMC for LBW infants as an alternative to conventional neonatal care, both before and after initial stabilisation, and examined its beneficial and adverse effects. The findings showed that KMC significantly lowered the risk of mortality at discharge or 40 to 41 weeks' postmenstrual age by 40% compared to conventional care (RR 0.60, 95% CI [0.39 to 0.92], p=0.021; I^2=0%; 8 studies/1,736 infants). Furthermore, KMC infants exhibited a significant 33% decrease in mortality risk during the latest follow-up (RR 0.67, 95% CI [0.48 to 0.95], p=0.026; I^2=0%; 12 studies/2,293 infants) (25).

While KMC is primarily known for its benefits within the hospital setting, a few studies have shown that it can be used safely and effectively during transport. Several studies on KMC transport have reported that it offers several clinical benefits over conventional incubator transport, especially for low birth weight or preterm infants. These benefits include improved cardiorespiratory stability during transport, potentially reducing jarring motion, and enhancing the mother–infant bond. Sontheimer *et al.,* in a study of 31 stable preterm and term infants in the kangaroo position in Germany (29), reported stable heart rate, respiratory rate, oxygen saturation, and rectal temperature during all kangaroo transports in ambulances lasting 10 to 300 minutes. They also discovered that KMC transport helps maintain a more stable breathing pattern and heart rate for the infants. In contrast, incubator transport can interfere with the transfer process in and out of the incubator.

The potential of KMC transport to reduce neonatal mortality, despite the widely reported positive physiological benefits of its use in health facilities, is underreported, and further large-scale studies are needed to quantify its effect in mitigating the high neonatal mortality rates in LMICs.

8.2.2 Social and cultural context

This study has identified cultural views held by mothers, contextual circumstances, and health system characteristics, such as an organised referral and transport system, as significant factors in the acceptability of KMC transport. The association between social and cultural norms and KMC utilisation is well established in several LMIC studies. For example, in some cultures in India, KMC dressing dishonoured cultural and traditional dressing and was found to be a barrier to its adoption (142). Studies from Ghana and Bangladesh have reported that the cultural tradition of mother–infant confinement for several days after delivery enhanced the mother's attention to the baby, and the cultural tradition of warming infants and infrequent bathing made it easier to utilise KMC (217, 218). The open-blouse method of dressing among newly delivered mothers, which is common in Ghana and other Sub-Saharan African countries, also suits KMC practice. These cultural and societal norms fed into our quantitative study, as many mothers who were educated about the study consented to participate. In the qualitative phase, mothers felt satisfied knowing that their babies were securely fastened to their chests during transport. A few mothers expressed concerns about the babies' small size and some discomfort during the journey.

Some cultural norms, as reported in the literature, can also be barriers to KMC use and, in effect, to KMC for transport. Mothers who gave birth to low birth weight infants in some studies felt inferior as women and had a feeling of incompetence in giving birth to these

small babies. This is because of the societal belief that low birth weight infants and preterm babies have poor survival, and mothers therefore had some reluctance to commit to emotional and physical bonding, as well as the fear of being ridiculed by society, which prevented them from KMC utilisation (217–220). There is evidence that in some societies, mothers had difficulty with very small newborns in the kangaroo position and believed the baby was too small to be in that position, possibly due to insufficient formal KMC training or knowledge of its benefits (219,220)**.** This barrier to the utilisation of KMC was evident in the quantitative phase of the study, with some mothers declining to participate, as they felt the babies were too small at birth. The physical size of the baby, which parents rightly conceive of as fragile, may, however, not be the sole reason for not participating in the study. Some mothers in the qualitative study shed more light on other concerns about the well-being of the infants during transport, which was a consideration for parents and families. For example, concerns included not being able to see the baby's face clearly, concerns about weather conditions, finding a comfortable position that worked for both mother and baby, and ensuring the baby was correctly handled in the KMC position. While some of these concerns can be addressed through education on KMC practices, the role of health workers in facilitating the transfer to enhance confidence and trust among mothers regarding KMC transport, when possible, needs further exploration in a larger study.

It is interesting to note that although some studies have indicated that the KMC practice was not culturally acceptable in Bangladesh, Ethiopia, India, and Ghana because it was customarily taboo to carry the infant at the front, our study found no such viewpoints from mothers or healthcare professionals (218,221). Mothers interviewed as part of the qualitative study overwhelmingly accepted the intervention.

8.2.3 Healthcare service strengths/barriers

Evidence-based neonatal therapies, such as KMC, are often scaled up depending on the strength of health systems. Staff shortages, high staff turnover, an insufficient number of trained healthcare professionals, a lack of ambulatory services needed to transport mothers, long distances, no public transportation options, and poor road conditions have been reported as common healthcare system challenges to effective KMC implementation in LMICs (222). Most of the neonates transported in our study used taxis or private vehicles, with only about 30% using ambulances, which reflects current practice in Ghana and many other Sub-Saharan African countries. However, most of the mothers in our study were comfortable and felt they were providing an essential service to their babies by being present during transport to provide the warmth and security they needed. The inadequate staff numbers in the participating facilities meant that none of the transfers in the study was accompanied by trained health personnel. Further research into the role of health workers in fostering parental confidence and monitoring the infants during KMC transport is needed. Also, the use of private transport in resource-constrained settings urgently needs to be optimised for KMC transport.

8.2.4 Parental and healthcare professionals' buy-in

Acceptance of and willingness to actively support and participate in KMC transport are influenced by several factors, including experiences and knowledge of the intervention among both mothers and healthcare professionals. In a Swedish study of parents' experiences of the kangaroo position during neonatal ground ambulance transport, the overarching theme that emerged was the uninterrupted closeness chain (30). Parents reported that staying with and holding their infant in the KMC position throughout ground

ambulance transportation, which extended the time they spent close to their infant, further strengthened their sense of being parents. The mothers in our study similarly echoed this positive parental sentiment. Additionally, in the Swedish study, parents reported that they understood the infant had been kept under observation during transportation but did not feel the need to check the monitor because they could sense the infant's well-being from the KMC position (30). The parents' role was confirmed as the knowledge they possessed about their baby's behaviour and needs was taken seriously by the accompanying neonatal nurse. The parents clarified that they could protect their infant's interests by keeping the infant close to them; in this way, the infant's well-being could always be monitored, and the baby could be soothed when necessary. For parents, the KMC position during ground ambulance transport was natural, as they believed it provided a supportive environment for their infants (30).

These positive buy-ins from the Swedish study were confirmed in our current study and are positive enablers of the acceptance of KMC for transport in the subregion. Even though there were no accompanying healthcare professionals in our study due to limited staffing in the units, the parents reported similar experiences of feeling valued and having their opinions about their children's care considered.

The uniqueness of KMC in providing comfort and closeness was also expressed in another qualitative study on KMC, albeit not in its use for transport. The mothers described the skin-to-skin contact with, and closeness to, the preterm infant as something they valued, and involuntary physical separation as something they had to accept and adapt to (223). Parental and healthcare professionals' knowledge of KMC is vital to the acceptability and successful implementation of KMC transport. Studies from Ethiopia and Nigeria found that

maternal use of KMC was facilitated by knowledge of the method, family support, and correct infant positioning. Conversely, its use was impeded by a lack of knowledge regarding the technique itself, proper positioning, required duration, and guidance on appropriate infant clothing (221,224). An Indian study further explained that when mothers had previous experience with a low birth weight infant, this facilitated acceptance, and they provided the infants with KMC, whereas the lack of information about the associated vulnerabilities of the low birth weight infants in some mothers prevented the initiation of KMC (217). Parents of low birth weight infants in a Malawi study accepted the standardised wrap because it was easy to use and supported sleep and breastfeeding during KMC compared with the usual cover cloth mothers use (225). In our study, as in the Indian study, some parents were lost in recruitment because they were concerned about the size and well-being of their infants. Although none of the mothers in our study had prior knowledge of KMC, they all agreed to participate due to the trust and education given to them by the recruiting healthcare professionals. Healthcare providers' buy-in is, therefore, essential for the effective implementation of KMC and KMC transport. Parental concerns about infant well-being due to small size, fragility, and vulnerabilities, as well as monitoring during KMC transport, are crucial factors that must be addressed to build parental confidence throughout the transport.

In a systematic review of enablers and barriers to the uptake of Kangaroo Mother Care (222), several factors affecting healthcare workers' buy-in to KMC surfaced. Some healthcare workers believed that newborn care was not a priority in their institution (226). Others perceived KMC as a disadvantage to nurses because the mother had to remain in the hospital (227). In other cases, KMC was cited as the 'poor man's alternative' for low-income

nations and as a sub-standard type of care (228). For nurses who had doubts regarding KMC and did not accept it because of a lack of belief in KMC, endorsement by more senior nurses allowed them to see the benefit of KMC and enhanced nurse buy-in (229,230).

In the Swedish study by Lundqvist *et al*. on parents' experiences of the kangaroo position during neonatal ground ambulance transport (30), the parents reported that the transferring nurse asked about their experiences with their child's behaviour and needs, which was an important consideration for them. They also discovered that the ambulance nurses made sure that the mothers were in a comfortable position on the stretcher, thus creating a feeling of being cared for. In our research, we were unable to examine nurses' contributions to parents' experiences during transportation because there were insufficient nurses at the participating facilities. This could therefore be an important area for future research to establish the mechanisms by which it contributes to KMC transportation via public transportation.

8.2.5 Education

The concept of KMC is especially beneficial for low- and middle-income healthcare settings, as it emphasises the mother's care of the newborn under the guidance of healthcare professionals, rather than relying on advanced technological resources. Therefore, sound knowledge of the intervention and its extension to transportation is imperative for both parents and healthcare professionals, who are key partners in its success.

In the quantitative phase of our study, mothers who lacked prior knowledge of KMC and its use in transporting neonates consented to participate after being educated by nurses/midwives. The qualitative phase provided further understanding of the high

acceptance, with mothers disclosing that their participation was, in part, due to the trust they had in the care and information provided by the healthcare professionals. Both the mothers and the healthcare professionals agreed that education on the intervention was necessary to allay maternal anxiety during the transfer and to bridge the gap between awareness and practical knowledge among healthcare professionals. Several studies support the importance of education in the successful practice of KMC. Healthcare professionals who receive education are better prepared to apply KMC, including monitoring the infant's health, encouraging breastfeeding, and practising skin-to-skin contact (222). The use of KMC is more likely to be promoted and supported by healthcare professionals who are knowledgeable about it and feel comfortable using it (231).

For mothers, education and knowledge about the benefits of KMC (better temperature regulation, breastfeeding success, and bonding) increase their willingness and ability to practice KMC (143). Educating mothers will enable them to overcome their doubts and misconceptions regarding KMC and develop positive feelings towards KMC, which will, in turn, give them self-confidence in their ability to care for their preterm or low birth weight infants through KMC (232). Education can be an essential factor in overcoming barriers to implementing KMC transport, including a lack of knowledge, limited resources, and cultural beliefs. Lastly, education can foster a more enabling environment for KMC transport implementation by raising awareness and dispelling misconceptions.

The ideal time for KMC education and awareness is essential to its acceptability. This process should ideally commence during antenatal care to help mothers and families understand its benefits, especially for preterm and low birth weight infants (233). This forward-looking approach empowers mothers to learn about KMC, enhancing acceptance

and implementation. Education should continue immediately after birth, emphasising KMC's importance for newborn health, akin to antenatal breastfeeding education (234). Support groups for mothers practising KMC can provide essential peer support and information (234), allowing them to share experiences and assist those considering KMC and, by extension, KMC transport.

8.2.6 Implementation

The successful implementation of KMC transport requires a holistic approach to addressing all the health system building blocks defined by the WHO (51), as previously described in chapter 2. It involves addressing not only infrastructure and transport challenges but also human resource inadequacies, including a shortage of healthcare professionals, limited/ inadequate knowledge among parents and healthcare professionals, poor communication between referring facilities, lack of leadership buy-in, and improved access to adequate and consistent training for healthcare workers. To facilitate access to KMC training, online work-share technologies can be employed, as in the United States, which allow communication between staff who are unable to find a common time for training (235). However, in a limited-resource setting where internet access may not always be reliable, the South African model, in which hospitals receive visits from facilitators who discuss KMC using workbooks, videos, and teaching posters, may be more effective for implementing KMC transport (236). In our study, we used KMC posters (Appendix J) to good effect from the initial sensitisation work and throughout the project to keep mothers and families aware of KMC practice.

Isolated healthcare worker training on KMC transport without leadership (senior hospital administrators and heads of medical and nursing teams) training and buy-in would be a barrier to KMC transport implementation. This has been evident in several studies on KMC

implementation in neonatal units in LMICs. In published work about some of this selective training from LMICs, it has been reported that trained health workers in Uganda were instructed to implement KMC in the facility without the necessary resources (236–238). Healthcare workers who had been trained in KMC served as hospital pioneers, having to win over not only mothers to the value of KMC, but also the facility leadership, who were not obligated to undergo training. Some had to negotiate with facility leadership to secure the necessary resources to enable the participation of the parents in KMC (e.g., chairs, beds, and private rooms) (237). In some instances, trained healthcare workers had to find time to train both mothers and leaders amid staffing shortages (238).

It is vitally important to have uniform guidelines with checklists for mothers and to ensure continuity of care, which would be adhered to by facilities with effective communication and coordination among the facilities. Facilities and policymakers need to come together and discuss more practical KMC transport guidelines and potential adjustments to accommodate local cultural and societal values. Focused KMC transport to facilities that commonly deliver preterm and LBW infants and scaling up to community health workers who cover home births could be more resource efficient, as already called for by Bergh *et al*. (237). Education and training on KMC transport should be based on the same fundamental understanding of the concept as well as complemented by the development of awareness by dedicated 'champions', multidisciplinary teamwork, and sustained efforts from senior management, as has been demonstrated from a study in India where the presence of physician champions improved the practice of KMC (239). It should be built on evidence from high-quality research, implemented consistently with current best practices in education, and contextually relevant and operational.

8.3 Contributions of this research work

There are several ways in which this research programme makes positive contributions to the field of study. First, this research programme has provided a comprehensive overview of current neonatal transport practices in SSA. This review, the first to focus primarily on the SSA region, highlights the pervasive lack of coordination in the transport process and notes that no study has explored the use of cost-effective interventions in this area. It also provides an update on the only systematic review of neonatal transport in developing countries, which was conducted ten years ago (83).

It provides unique insight into an evidence-based intervention that can help reduce neonatal mortality and accelerate progress towards meeting the SDG 3 target in a Sub-Saharan African country. This is the first time such an enquiry has been made in Ghana and, to our knowledge, any Sub-Saharan African country. The discovery that KMC transport using available modes of transport presents a viable alternative to conventional care, without increased harm, and could potentially benefit thermoregulation and survival rates in transferred neonates is novel.

As previously discussed, a single previous study from the Philippines explored the feasibility of KMC transport using available modes of transport. Our study, the first of its kind from Sub-Saharan Africa, provides evidence of the feasibility of KMC transport and, importantly, the use of available public transport for the process. This is significant, as many governments in SSA are not actively pursuing improvements in the ambulance–patient ratio at the national or regional level. The subregion also lacks dedicated neonatal transport teams.

In addition to the quantitative analysis, the qualitative phase of this study sought to understand the perspectives of mothers and healthcare professionals on the intervention. It revealed that not all previously reported barriers, such as carrying on the front, were applicable in the Ghanaian context, highlighting the importance of identifying local facilitators and barriers to implementation. Considering the perspectives of these professionals and mothers is essential to shaping the design of a larger study and to the successful implementation of the intervention.

8.4 Strengths and limitations

The strength of our study is its novel application of KMC practice in neonatal transport in Sub-Saharan Africa, which has the highest rates of neonatal mortality. It was a prospective study that had the key benefit of discussing the feasibility of employing KMC during transfer using available land transport (taxis and private cars), with babies arriving at the referral centre not being worse off physiologically compared to the current practice of wrapping them in a cloth and carrying them in the caregivers' arms. The qualitative study presented a mix of perspectives from mothers and healthcare professionals on KMC transport and how to improve the process. The interviews were offered in multiple languages so that they were accessible to all the women from the area who participated. All the women invited took part, so there was no self-selection bias, which is where a study only manages to recruit those with positive views. Significantly, this study adds to the limited evidence on KMC transport in LMICs.

8.4.1 Limitations

The study had several limitations in both quantitative and qualitative aspects. In the quantitative aspect, the clinical care of transferred neonates in CCTH may have affected mortality rates between the two groups and warrants further exploration in a larger study. The differences in travel distances and the absence of accurate travel time data between the two groups constituted a potential bias that could directly influence the outcomes. However, none of the transfers included an accompanying nurse or midwife, and ambulance transfers were carried out by paramedics who neither monitored nor provided care during the transfer. The observed differences, therefore, could not have been attributable to differential care during transport.

The feasibility study was not intended to identify statistically significant differences between the two groups; thus, the lowered mortality rates should not be regarded as conclusive. Any future research must be meticulously adjusted not only for travel times and the care provided during transport, as previously mentioned, but also for neonatal factors such as birth weight, gestational age, condition at birth (e.g., Apgar score), and maternal factors such as antenatal risk factors, the mother's socioeconomic status, type of household fuel used, parity, and health conditions. Additionally, attention should be paid to the timing of the first feeding, which might occur sooner with KMC, potentially contributing to better outcomes with this method.

We acknowledge the potential for social desirability bias among mothers during the interviews. To minimise this bias, the interviews were conducted in quiet rooms outside the neonatal unit exclusively by research staff, and data confidentiality was maintained after the interviews were completed.

The research design also incorporated specific strategies to mitigate potential biases that could threaten the validity of the findings. Acknowledging the potential for power disparities between interviewers and participants to induce acquiescence or interviewer bias, several measures were implemented. These included establishing rapport, clearly articulating the study's purpose, and assuring participants that their responses would not affect their clinical care. Furthermore, the participants were explicitly positioned as experts on their own experiences to affirm the value of their perspectives and empower their contributions.

To address potential researcher bias—particularly confirmation and analytic bias arising from the team's involvement in both qualitative analysis and awareness of the quantitative feasibility results—several procedural safeguards were employed. These included independent analysis of qualitative data by two researchers who were not directly involved in data collection. Additionally, during the data integration phase, discrepancies between the quantitative and qualitative datasets were carefully examined to challenge preconceptions and ensure analytical rigour.

Another limitation is the lack of perspectives from healthcare professionals on transport conditions and monitoring during transport. This could readily be addressed in a large-scale study with dedicated healthcare workers assigned to accompany mothers.

8.5 Recommendations for future work

8.5.1 Implications for clinical practice and future research

The study identified several measures that have the potential to increase the uptake of KMC transport. These include addressing the challenges identified in this study and enhancing the education of health workers and parents.

1. The mother's acceptance of KMC transport suggests that the intervention can be introduced earlier, perhaps at antenatal clinics in peripheral maternity units, to increase awareness and offer a viable alternative method of transfer for families.
2. The empowerment experienced by the caregivers can be harnessed to improve knowledge about KMC transport in the community and provide opportunities for them to function as role models.
3. Peripheral maternity units can be empowered to consult with local transport organisations to identify and educate drivers on safe and rapid transport for neonates using KMC.
4. Regular and enhanced education of healthcare professionals on KMC transport can be a channel for improved KMC utilisation in the various neonatal units in Ghana.

To definitively evaluate the efficacy of KMC during neonatal transport using existing modes of travel in low- and middle-income countries, particularly in Sub-Saharan Africa, large-scale, multi-centre randomised-controlled trials are imperative. A primary methodological challenge is that many peripheral maternity units, which are logical trial sites, may have low incidences of preterm and low birth weight deliveries, thereby limiting enrolment. To overcome this limitation and ensure an adequate sample size, a multinational or multi-regional trial design across several SSA nations, or a design involving several neonatal units across Ghana, is recommended.

Securing substantial international funding is a prerequisite for such a robust investigation. A collaborative research consortium would be essential to standardise data collection, conduct parallel qualitative studies, and adapt the intervention for diverse socio-ethnic contexts. The trial should incorporate family education, dedicated staffing for transfer

support, and process evaluation to assess implementation fidelity. Ultimately, pooling data from multiple distinct sites will yield a sample size sufficient for rigorous statistical analysis, enabling the detection of clinically significant outcomes and the generation of high-quality evidence to inform public health policy.

To further establish the value of KMC transport, longitudinal studies comparing its long-term developmental outcomes with those of conventional care are warranted. Given the multifaceted nature of this intervention, future trials should be guided by established frameworks for complex interventions (e.g., those of the Medical Research Council/NIHR) (192). While KMC itself is straightforward, integrating it into transport is complex. The KMC technique does not solely determine outcomes; they are also moderated by variables such as transport time, infant clinical status, and gestational age. Furthermore, implementation requires significant investment in training, logistics, and community engagement. A complex intervention framework provides the necessary structure to navigate these intricacies, ensuring a comprehensive evaluation that includes stakeholder engagement and a full economic analysis.

In the current Ghanaian context, the application of KMC can be limited to controlled transfer scenarios, such as dedicated ambulances or private vehicles, where a paramedic or healthcare professional can directly supervise both mother and infant. This provisional practice is contingent on evidence from future robust clinical trials.

8.6 Summary

This concluding chapter achieved three primary objectives. First, it interpreted the study's key findings in dialogue with the existing body of literature. Second, it offered a critical reflection on the research process, evaluating its methodological strengths and acknowledging its constraints. Third, it articulated the unique scholarly contributions generated by this work. The chapter culminated in a series of targeted recommendations for future research, designed to address the gaps and opportunities identified herein.

Chapter 9: Conclusion

9.1 Introduction

This thesis presents a programme of mixed-methods research in the form of an article-based output. Two papers, published in peer-reviewed scientific journals, and a third paper, under review, make up the constituent parts of the thesis. This chapter examines the aims and objectives of the research and clarifies its contribution and impact.

9.2 Review of aims and objectives.

The primary aim of this research programme was to address the question,

Is the implementation of KMC in neonatal transport feasible in Ghana?

This question was addressed through the investigation of three research objectives:

- Establish what is known in the current research literature regarding neonatal transport practices in Sub-Saharan Africa.

This objective was met through a systematic review of the available literature, as presented in chapter 3. The review highlights significant challenges in neonatal transport in the subregion, including poor referral practices, poor communication between facilities, reliance on informal transport methods, and poorly equipped ambulances, all of which put vulnerable neonates at risk. Notably, despite its proven benefits, no studies have reported the use of KMC in any transport scenarios.

- Conduct a feasibility study on utilising KMC for transporting preterm and low birth weight neonates via Ghana's existing transport infrastructure.

This research objective was addressed through the conduct and analysis of a two-arm non-randomised controlled cluster study between August 2022 and April 2023 in Cape Coast, Ghana, which compared the outcomes of preterm and LBW infants transferred from eight peripheral maternity units to CCTH, either in the KMC position or by existing conventional methods. This is presented in chapter 5. Analysis of transport modalities revealed a reliance on taxis and private vehicles. Crucially, KMC transport was associated with no adverse events and a nonsignificant trend toward higher neonatal temperatures at admission. Although limited by statistical power, these data indicate that KMC is not inherently riskier than standard in-arms transport and can be feasibly integrated into current transport systems in Sub-Saharan Africa for vulnerable neonatal populations. This offered crucial insights to guide the creation of a comprehensive study to assess the effectiveness of KMC during the transfer of neonates from peripheral birthing units to a central hospital, ultimately aiming to lower mortality and morbidity rates for vulnerable infants in Sub-Saharan Africa, a region with the highest infant mortality rates globally.

- Explore the perspectives of mothers and healthcare professionals on using KMC for neonatal transport in Ghana.

This objective was met through a qualitative study involving mothers and healthcare professionals, which included semi-structured interviews that were analysed thematically. This study, presented in chapter 6 in the format submitted for review, concluded that KMC transport using available transportation is highly acceptable to mothers and healthcare professionals. Effective, enhanced education for mothers and healthcare professionals on KMC transport is vital to successfully implementing the intervention.

9.3 Impact to date

This research programme has produced three research papers, two of which have been published in peer-reviewed journals. At the time of submission of this thesis on 26 May 2025, the metrics for these research outputs were as follows:

Okai E, Fair F, Soltani H. Neonatal transport practices and effectiveness of the use of low-cost interventions on outcomes of transported neonates in Sub-Saharan Africa: A systematic review and narrative synthesis. Health Science Reports. 2024 Mar;7(3):e1938.

Cited 7 times

Okai E, Fair F, Konadu HD, Darteh EK, Soltani H. Feasibility of the use of Kangaroo Mother Care in the transfer of preterm and low birth weight infants: a two-arm non-randomised controlled cluster feasibility study of neonatal transport in Cape Coast, Ghana. BMC *Pediatrics*. 2024 Dec 28;24(1):842.

Cited 3 times.

Locally, this research has heightened awareness of the need to establish optimal conditions for neonatal transfer to the Cape Coast Teaching Hospital Special Care Baby Unit. The findings have directly informed a more structured local transfer policy, which now mandates enhanced communication between peripheral facilities and the CCTH. Furthermore, the policy now explicitly recommends planned, professionally accompanied transfers utilising KMC where possible, superseding the traditional practice of carrying infants in parents' arms.

9.4 Summary

Through its mixed-methods design, this research programme makes a significant empirical and practical contribution to maternal and neonatal health. The findings not only address a critical evidence gap but also lay a foundational framework for developing targeted, cost-effective interventions to mitigate neonatal mortality in Sub-Saharan Africa, thereby supporting the achievement of Sustainable Development Goal 3, which aims to ensure healthy lives and promote well-being for all at all ages by 2030.

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Appendices

Appendix A: Author contribution to the included articles and copyright permissions

Outputs

Article A

Title:	Neonatal transport practices and effectiveness of the use of low-cost interventions on outcomes of transported neonates in Sub-Saharan Africa: A systematic review and narrative synthesis.
Authors:	Emmanuel Okai, Frankie Fair, Hora Soltani.
Full Reference:	Okai E, Fair F, Soltani H. Neonatal transport practices and effectiveness of the use of low-cost interventions on outcomes of transported neonates in Sub-Saharan Africa: A systematic review and narrative synthesis. Health Science Reports. 2024 Mar;7(3):e1938.
Contribution Statement:	This piece of work was led by Emmanuel Okai, who oversaw and was actively involved in all stages of the research process.
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Article B

Title:	Feasibility of the use of Kangaroo Mother Care in the transfer of preterm and low birth weight infants: a two-arm non-randomised controlled cluster feasibility study of neonatal transport in Cape Coast, Ghana.
Authors:	Emmanuel Okai, Frankie Fair, Hilda Konadu, Eugene K Darteh, Hora Soltani.
Full Reference:	Okai E, Fair F, Konadu HD, Darteh EK, Soltani H. Feasibility of the use of Kangaroo Mother Care in the transfer of preterm and low birth weight infants: a two-arm nonrandomized controlled cluster feasibility study of neonatal transport in Cape Coast, Ghana. BMC *Pediatrics*. 2024 Dec 28;24(1):842.
Contribution Statement:	This piece of work was led by Emmanuel Okai, who oversaw and was actively involved in all stages of the research process.
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Article C

Title:	Acceptability of Kangaroo Mother Care (KMC) in neonatal transport: A qualitative study on mothers' and healthcare professionals' perspectives on KMC transport in Ghana**.** **(Currently under review for publication in BMC *Pediatrics*)**
Authors:	Emmanuel Okai, Frankie Fair, Hilda Konadu, Prince Arkoh, Evans Ntim Eugene K Darteh, Hora Soltani
Contribution Statement:	This piece of work was led by Emmanuel Okai, who oversaw and was actively involved in all stages of the research process.

Appendix B: Protocol for PROSPERO registration for systematic review

Neonatal transport practices and effectiveness of the use of low-cost interventions on the morbidity and mortality of transported neonates in Sub-Saharan Africa: A systematic review protocol

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Abstract

Objectives

Poor pre-transport and intra-transport care are associated with early neonatal morbidity and mortality. The objective of this study is to provide a critical overview of research on neonatal transport practices and the use of low-cost interventions, including Kangaroo Mother Care (KMC), employed in neonatal transport, and their outcomes for neonates transported for specialised care in Sub-Saharan Africa, through a systematic review and narrative synthesis.

Study design

The study design is a protocol for a systematic review.

Methods

A comprehensive literature search will be conducted using the electronic databases CINAHL, EMBASE, MEDLINE, Web of Science, and Google Scholar. A manual search will be carried out of the reference lists of eligible studies for relevant papers. The search strategy will combine three key blocks of terms, namely: 'neonates', 'transport' and 'Sub-Saharan Africa', using database-specific subject headings and text words.

Two independent reviewers will screen and assess data quality and extraction for synthesis. Any disagreements during the data extraction and quality assessment stages will be resolved by consensus, with a third reviewer involved. Study quality will be assessed using the Mixed-Methods Appraisal Tool (MMAT), and a narrative synthesis will be undertaken to integrate and summarise the findings. Subgroup analysis will be conducted when data are available within countries, across different groups of neonates, and across different modes of transportation.

Ethics and dissemination

Approval by a research ethics committee is not required for this study, as the review only includes published, publicly accessible data. Findings from this review will inform research into the use of Kangaroo Mother Care in neonatal transport in Ghana. We will publish our findings in a peer-reviewed journal as per the Preferred Reporting for Systematic Review and Meta-analysis (PRISMA) 2020 Guidance.

Registration

PROSPERO registration CRD42022352401

Background

Globally, significant progress has been made in child survival since the Millennium Development Goals (MDGs) were instituted over two decades ago to tackle the indignity of poverty. Progress in reducing newborn mortality has, however, lagged behind the reduction in overall deaths in children under the age of 5 years.

The global under-5 mortality rate (U5MR) fell from 90·6 deaths per 1000 live births in 1990 to 42·5 per 1000 live births in 2015. During the same period, the annual number of under-5 deaths dropped from 12·7 million to 5·9 million (1), significantly below the 2015 (MDG) target of a reduction by two-thirds. Comparatively, the decline in neonatal mortality has been slower than that of post-neonatal under-five mortality: 47 per cent compared with 58 per cent globally. The portion of neonatal deaths among overall under-five deaths increased from 40% in 1990 to 45% in 2015 (2), with several regions in the worst hit areas exceeding 50 per cent mortality (3). The neonatal mortality rate fell from 36 deaths per 1,000 live births in 1990 to 19 in 2015, and the number of neonatal deaths declined from 5.1 million in 1990 to 2.7 million in 2015 (2).

The Sustainable Development Goals (SDGs) have a child survival target for all countries to achieve a U5MR of 25 or fewer deaths per 1000 livebirths by 2030 (SDG target 3.2.1) and a neonatal mortality rate (NMR) of at least 12 per 1000 live births by 2030 (SDG target 3.2.2) (4). Low- and middle-income countries (LMICs) bear the major brunt of this health disparity, with Sub-Saharan Africa leading with a neonatal mortality rate of 27 deaths per 1000 live births, accounting for 43% of global newborn deaths, followed by central and southern Asia (23 deaths per 1000 live births) (5).

The primary causes of neonatal mortality (prematurity, congenital anomalies, birth asphyxia, and severe infections) have received significant attention in terms of efforts toward their prevention, but the development of robust systems must complement these to care for sick newborns, including safe and appropriate transfer processes.

Neonatal health service delivery and referral systems in LMICs.

LMICs face significant challenges across almost all of the World Health Organization's health (WHO) system building blocks. These are service delivery, health workforce, health management information systems, access to essential medicines, financing, leadership and governance, and community engagement (6). Readily available access to skilled attendance

at birth remains a significant challenge in many resource-constrained settings (7). Although the proportion of births at health facilities has generally increased in many countries, at least half of all births in developing countries occur without skilled birth attendants (8). The consequence of this disparity in health facility delivery translates into many neonates in resource-constrained settings being delivered in settings without adequate resources for newborn care, in suboptimal and often indeterminate conditions. It would require transportation to better-equipped facilities where appropriate, special or intensive care can be provided.

According to WHO statistics, about one-third of neonatal deaths in 2019 occurred on the day of birth, with close to three-quarters happening in the first 7 days (9). Many newborn deaths are a consequence of a lack of contact with the health system or a lack of transfer systems to improve access to higher-level facilities (10-12). Prompt attention to and referral of sick newborns might significantly reduce the high mortality on the day of birth (13).

Neonatal transport in low- and middle-income countries.

Poor pre-transport and intra-transport care are associated with early neonatal morbidity and mortality. Severe neonatal morbidity, particularly hypothermia, hypoglycaemia, hypoxia, and hyperthermia, may result from poor transportation and inadequate care, resulting in an increased risk of neonatal mortality (14). Undoubtedly, inutero transfer is the safest and most secure form of transfer, but the unpredictability of preterm delivery and perinatal illness has resulted in the continued need for an effective neonatal transport system (15). Sick newborns within the catchment areas of established specialised neonatal centres remain at risk of adverse outcomes because of poor access, contributed to in part by a lack of coordinated neonatal transport service and, oftentimes, unsafe transfer practices. A structured and organised neonatal transport system can improve outcomes for newborns at high risk of adverse conditions who are delivered far from the established tertiary centres (16).

The Sub-Saharan region has differing economic and health statistics compared to other low- and middle-income regions. 40% of the world's population currently lives below the US$1.90-a-day poverty line, with Sub-Saharan Africa accounting for 66 per cent of the global extreme poor population (17).

Challenges in every sector of the health system regarding newborn care and the absence of well-established ambulance service in most LMICs lend itself to the need to explore the possibility of employing cost-effective but evidence-based, life-saving processes in the neonatal transfer process which would inform technical guidelines for use by health care professionals, facilities, and organizations responsible for setting health system priorities and policies surrounding the transport of neonates in LMICs. The use of Kangaroo Mother Care and other alternative methods to maintain thermal stability during neonatal transport is not well studied in LMICs, yet several published studies on neonatal transport have identified this as an area for future research.

Objectives

To systematically review the literature on neonatal transport practices in Sub-Saharan Africa and their contribution to morbidity and mortality in neonates transported for specialised care.

Review questions.

1. What transport organisations and practices are available for neonatal transport into hospitals in Sub-Saharan Africa?
2. What evidence-based, low-cost interventions, including Kangaroo Mother Care, are employed in neonatal transport in the region, and how do these impact morbidity and mortality of transported neonates?

Methods

Study design

The study design is a protocol for a systematic review. It will include peer-reviewed primary empirical quantitative, qualitative and mixed methods studies. The study protocol for this systematic review is prepared according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) guidelines.

Participants or population

Any study primarily focused on all neonates, defined as newborn infants with a chronological age of 28 days or less without regard to the postmenstrual age at birth, who are referred from the community or a primary health care facility to a designated facility where specialised neonatal care is available, irrespective of the distance.

Intervention(s), exposure(s)

All interventions to improve the outcome of referred neonates are relevant to this review. These include all pre-transport interventions, e.g., training in communication for medical personnel, inter-facility pre-referral communication, interventions to refine or upgrade existing transport methods, the introduction of new transport methods or equipment, and methods to improve physiologic stability.

Comparator(s)/control

We will include all articles, whether or not a control group is used.

Context

Articles from all 49 Sub-Saharan African countries studying the transfer of neonates from primary, secondary or tertiary settings to another healthcare facility for continuing care purposes.

Any transport will be considered: ground, air, repatriation, or wait-and-return appointment.

Main outcome(s)

The primary objective of this review is to synthesise evidence on the outcomes (morbidity and mortality) of various transport practices for neonates requiring inter-facility or community-to-hospital transport in Sub-Saharan Africa.

Additional outcome(s)

A secondary objective is to identify evidence-based, cost-effective interventions used in neonatal transport in the region and to define their components, including the stage at which they are employed (pre-transfer, during, or post-transfer), who administers them, and the outcomes measured.

Inclusion criteria

All peer-reviewed publications on neonatal transport, describing transport modalities/processes and outcomes within Sub-Saharan Africa, will be assessed. There will be no time restrictions on publications; there will be no language limit; however, searches will be restricted to studies from Sub-Saharan Africa.

Exclusion criteria

Case reports, protocols, editorials, commentaries, or studies on neonatal transport not published from Sub-Saharan Africa. For studies with uncertainty about meeting inclusion criteria, or where relevant data cannot be extracted from the study report, the authors will

be contacted for additional information and/or further data. If this is not forthcoming, the study will be excluded. In studies of mixed samples where only a proportion of the study population meets the inclusion criteria (e.g., only a proportion of transported infants are neonates, or communication was partly about the maternal pre-labour transfer), the study will be included if relevant data can be extracted. The authors will be contacted if relevant data cannot be extracted; if this is not available, then the study will be excluded.

Settings

For this review, studies from all 49 countries within the subregion, including Djibouti, which is not included in the World Bank repository solely due to administrative reasons (18), will be considered.

Search strategy

A comprehensive search of the following databases will be undertaken for the identification of peer-reviewed literature: CINAHL, EMBASE, MEDLINE, and Web of Science, as well as Google Scholar and the reference lists of included articles.

The search strategy will include terms related to transport or transfer, neonates, and interventions. Boolean logic will be applied to ensure a comprehensive combination of search terms.

The searches will be conducted between 11th and 22nd April 2022, and a re-run will be conducted before the final analysis, scheduled for 15th to 26th August 2022. No restrictions will be placed on the publication date or language of publication, and searches will be conducted for relevant papers published up to August 2022.

However, the studies included will be restricted to only those from Sub-Saharan Africa.

Data extraction (selection and coding)

Articles retrieved using the search strategy will initially be screened by title and abstract against the inclusion criteria. Full texts will then be retrieved and assessed for eligibility. The screening will be undertaken by the lead reviewer, Emmanuel Okai (EO) and checked by two other reviewers, with any disagreement over potential article relevance resolved through discussion. Study authors will be contacted via email correspondence for any relevant missing data or clarification. Duplicates will be eliminated using RefWorks.

Once eligible papers have been identified, they will be read in full text independently by two reviewers for inclusion, and the primary reviewer (EO) will extract study characteristics and

outcome data from the included studies using a predefined data extraction form (Excel spreadsheet), which will be subsequently checked for accuracy by two other reviewers. Reasons for excluding studies will be provided, and the screening of search results will be presented in a PRISMA flow chart.

Data would be extracted under the following headings

Title, author, year of publication, country of origin, study design, population (size, term, preterm, low birth weight). Other specific data to be extracted include: type of transfer (ambulance- ground/air, public transport, walking, cycling).

Accompanying parents or healthcare professional.

Intervention types (e.g., KMC, focused on communication, physical/practical, social, economic, psychological or emotional well-being).

Intervention timing (pre-transfer, during transfer, post-transfer short or long-term);

Intervention by whom (transport team member, midwife/neonatal unit staff, specialised staff such as a psychologist, occupational therapist, social worker, etc.).

Intervention effectiveness testing (what scale/tool was used and the effectiveness rating),

Outcomes: mortality, hypothermia, hypoglycaemia, hypoxia, apnoea, respiratory distress.

Risk of bias assessment

As the review will include quantitative, qualitative, and mixed-methods studies, the quality of the included studies will be assessed independently by two reviewers using the Mixed-Methods Appraisal Tool (MMAT) v. 2018 (19). The MMAT includes two screening questions, followed by five categories of study design assessment: qualitative, quantitative (non-randomised), quantitative (randomised), descriptive, and mixed methods. Within each study category, there are five methodological quality criteria. These criteria relate to the appropriateness of methodology, data collection techniques and data analysis techniques. Each included study will be thoroughly appraised using all assessment criteria, independently by two reviewers, with any disagreements discussed with a third reviewer. No studies will be excluded based on their quality, but the narrative synthesis will comment on the quality of the identified studies.

Strategy for data synthesis

Due to the expected heterogeneity of studies, a narrative synthesis of the results will be performed. This will include a narrative discussion of methods of neonatal transportation, the adequacy or otherwise of the transfer process, and the outcomes for transported neonates.

Additionally, the cost-effective interventions employed, whether adapted or not, and their effectiveness in the transport process would be described.

Where sufficient and relevant data are available, subgroup analyses would be undertaken for the various categories of neonates (term, preterm, and low birth weight) across varying transport modalities.

The screening results will be reported in a PRISMA flow diagram.

Conclusion

This systematic review of neonatal transport in Sub-Saharan Africa will provide a detailed summary of current neonatal transport modalities and organisation, as well as evidence on the effectiveness of low-cost interventions to improve the outcomes of transported neonates from primary health care to specialised care centres.

Subject index terms

Infant, newborn; intensive care units, neonatal; intensive care, neonatal; transfer, transport, Sub-Saharan Africa, developing countries, LMICs.

Author statements

Ethical approval

Not required for protocol papers of systematic review

Funding

This review is being conducted as part of the lead reviewer's self-funded split-site PhD

Competing interests None declared.

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Appendix C: Supplementary data for systematic review

Search terms

A combination of keywords used.

1. #1 neonat*
2. #2 neonatal
3. #3 preterm
4. #4 prematurity
5. #5 premat*
6. #6 low birth weight
7. #7 small for gestational age
8. #8 (MH " neonates")
9. #9 (MH " neonatal Care")
10. #10 (MH "prematurity")
11. #11 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11
12. #12 transport*
13. #13 evacuation
14. #14 retrieval
15. #15 stabilisation
16. #16 ambulance
17. #17 car
18. #18 lorry
19. #19 bicycle
20. #20 transport team
21. #21 transport service
22. #22 evacuation team
23. #23 telephone
24. #24 communication
25. #25 Kangaroo Mother Care
26. #26 KMC
27. #27(MH " neonatal retrieval")
28. #28 (MH "neonatal transport")
29. #29(MH " patient transfer")
30. #30 (MH "neonatal referral")
31. #31 #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #28 OR #29 OR #30
32. #32 "neonatal mortality''
33. #33 "neonatal death''
34. #34 neonatal survival
35. #35 preterm death
36. #35 preterm survival
37. #37 "low birth weight mortality''
38. #38 " low birth weight survival''
39. #39 (MH " neonatal death")
40. #40 (MH " preterm death")

#41 # 32 OR # 33 OR # 34 OR #35 OR #35 OR # 37 OR #38 OR 39 OR 40

41. #42 hypothermia
42. # 43 hyperthermia
43. #44 temperature
44. #45 "temperature control''
45. #46 hypoglycaemia
46. #47 blood sugar control
47. #48 hypoxia
48. #49 respiratory distress syndrome
49. #50 hyaline membrane disease
50. # 51 asphyxia
51. #52 hypotension
52. #53 sepsis
53. #54 apnoea

#55 #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54

54. #56 developing countries.
55. #57 low-income countries
56. #58 middle-income countries
57. #59 low- and middle-income countries
58. #60 Africa
59. #65 low human development index countries
60. #66 medium human development index countries
61. #56 #57 OR #58 OR #59 OR #60 OR #61 OR #62
62. #11 #31 AND #41 AND #55 AND #63
63. #11 #31 AND #41 AND #55 AND each of the following countries

Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo or DRC or democratic republic of Congo, Ivory Coast, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Swaziland, Togo, Uganda, Tanzania, Zambia, Zimbabwe.

Mixed Methods Appraisal Tool checklist

Neonatal transport practices and the effectiveness of the use of low-cost interventions on the morbidity and mortality of transported neonates in Sub-Saharan Africa: A systematic review

Table: Definition of methodical quality criteria for Mixed Methods Assessment Tool (sections 1 and 4)

Screening questions
S1. Are there clear research questions?

S2. Do the collected data allow to address the research questions?

Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.

1. Qualitative

1.1. Is the qualitative approach appropriate to answer the research question?

1.2. Are the qualitative data collection methods adequate to address the research question?

1.3. Are the findings adequately derived from the data?

1.4. Is the interpretation of results sufficiently substantiated by data?

1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?

4. Quantitative

4.1. Is the sampling strategy relevant to address the research question?

4.2. Is the sample representative of the target population?

4.3. Are the measurements appropriate?

4.4. Is the risk of nonresponse bias low?

4.5. Is the statistical analysis appropriate to answer the research question?

Mixed Methods Appraisal Tools scoring ratings.

Authors (year), Country	1.1	1.2	1.3	1.4	1.5	4.1	4.2	4.3	4.4	4.5	Score (%)
Njokanma *et al.* (1994). Nigeria						Y	Y	N	Y	N	60
Nalwadda *et al.* (2013). Uganda						Y	Y	Y	Y	Y	100
Roux *et al.* (1989). South Africa						Y	Y	Y	Y	Y	100
Dicko *et al*. (2010). Mali						Y	Y	Y	Y	Y	100
Ndiaye *et al.* (2003). Senegal						Y	Y	N	N	N	40
Enweronu-Laryea *et al.* (2008). Ghana						Y	Y	Y	N	Y	80
Teklu *et al.* (2020). Ethiopia	Y	Y	Y	Y	Y						100
Nlend *et al.* (2016). Cameroon						Y	N	Y	Y	Y	80
Accorsi *et al*. (2017). Ethiopia						Y	N	N	Y	Y	60
Tette, Edem *et al*. (2020). Ghana						Y	N	Y	Y	Y	80
Okonkwo *et al*. (2020). Nigeria,						Y	Y	Y	Y	Y	100
De Vries (2011). South Africa						Y	Y	Y	Y	Y	100
Abdulraheem *et al*. (2016). Nigeria						Y	Y	Y	Y	Y	100
Ashokcoomar *et al*. (2016). South Africa						Y	N	Y	Y	Y	80
Sory *et al.* (2019). Guinea						Y	Y	Y	Y	Y	100
Faye *et al*. (2016). Senegal						Y	Y	Y	Y	Y	100
Duduzile *et al.* (2013). South Africa	Y	Y	Y	Y	Y						100
Katamea *et al*. (2014). Congo						Y	Y	Y	Y	Y	100
Pieper *et al.* (1994). South Africa						Y	Y	N	Y	Y	80

Y = Yes N = No

Appendix D: Questionnaire for quantitative study

NEONATAL ADMISSION PROFORMA FOR CCTH

ALL QUESTIONS CONTAINED IN THIS QUESTIONNAIRE ARE STRICTLY CONFIDENTIAL

IDENTIFIER ***(LAST, FIRST INITIAL – MONTH/YR):***	☐ M ☐ F	**DOB:**

MATERNAL DETAILS						
AGE				**NO OF CHILDREN**	**AGE**	SIGNIFICANT HEALTH PROBLEMS ALIVE/DEAD
PARITY		**GRAVIDA**		**DETAILS OF CHILDREN**	☐ M ☐ F	
PRIOR TO PREGNANCY	☐ Y ☐ N	HYPERTENSION			☐ M ☐ F	
	☐ Y ☐ N	DIABETES			☐ M ☐ F	
	☐ Y ☐ N	HIV			☐ M ☐ F	
	OTHERS					
				PREVIOUS PRETERM BIRTH	☐ YES ☐ NO	IF YES GESTATION
				PREVIOUS MISCARRIAGE	☐ YES ☐ NO	

MARITAL STATUS: ☐ SINGLE ☐ COHABITING ☐ MARRIED ☐ SEPARATED ☐ DIVORCED ☐ WIDOWED

EDUCATION: ☐ NONE ☐ PRIMARY ☐ JSS ☐ SSS ☐ TERTIARY

OCCUPATION: ☐ UNEMPLOYED ☐ FARMING ☐ SALES & SERVICES ☐ CLERICAL ☐ PROFESSIONAL/MANAGERIAL ☐ SKILLED/ MANUAL ☐ UNSKILLED MANUAL ☐ STUDENT

HOUSEHOLD FUEL: ☐ ELECTRIC ☐ LPG/NATURAL GAS/BIOGAS ☐ CHARCOAL ☐ FIREWOOD ☐ KEROSINE ☐ CROP RESIDUE

AGE

THIS PREGNANCY					
BOOKING VISIT					
ANOMALY SCAN	☐ YES ☐ NO		**WEIGHT**	**KG**	FIRST TRIMESTER (DATE OF WEIGHT MEASUREMENT OR GESTATIONAL AGE FOR THIS WEIGHT MEASUREMENT)
SIGNIFICANT HEALTH PROBLEMS	☐ Y ☐ N	HYPERTENSION		**KG**	SECOND TRIMESTER
	☐ Y ☐ N	DIABETES		**KG**	THIRD TRIMESTER
	☐ Y ☐ N	HIV	**MEDICATIONS**	☐ YES ☐ NO	FOLIC ACID
	☐ Y ☐ N	HEPATITIS B		☐ YES ☐ NO	VITAMINS
	☐ Y ☐ N	SYPHYLIS		**OTHERS**	
BLOOD GROUP			**ALLERGIES**	☐ YES ☐ NO	

LIST ANY MEDICAL PROBLEMS DIAGNOSED

LABOUR AND DELIVERY

LABOUR	SPONTANEOUS	☐ YES ☐ NO		
	INDUCED	☐ YES ☐ NO	INDICATTION	
	PROM	☐ YES ☐ NO	IF YES, STATE HRS	
	CHORIOAMNIONITIS	☐ YES ☐ NO	STEROIDS GIVEN	☐ YES ☐ NO
	ECLAMPSIA	☐ YES ☐ NO	MGSO4	☐ YES ☐ NO

DELIVERY	GESTATIONAL AGE:	TIME:	BIRTH WEIGHT	
	PLACE OF DELIVERY ☐ HOME	☐ HEALTH CENTRE	☐ REGIONAL HOSPITAL	
	☐ CHIPS COMPOUND	☐ DISTRICT HOSPITAL	☐ TERTIARY HOSPITAL	
	ATTENDANT AT DELIVERY ☐ NONE	☐ TBA	☐ MIDWIFE	
	☐ PARENT	☐ NURSE	☐ DOCTOR	
	TYPE OF DELIVERY ☐ NVD	☐ FORCEPS	☐ VENTOUSE	
	☐ EMCS	☐ ELCS	☐ BREECH EXTRACTION	
RESUSCITATION	**APGAR SCORE** 1 MIN	5MIN	10MIN	
	ATTENDANT ☐ NONE	☐ TBA	☐ MIDWIFE	
	☐ PARENT	☐ NURSE	☐ DOCTOR	
	HAS ATTENDANT HAD RESUSCITATION TRAINING	☐ YES	☐ NO	

TRANSFER

TRANSFER PROCESS	DATE OF TRANSFER:	TIME OF TRANSFER:	TIME OF ARRIVAL:	
	WEIGHT ON ADMISSION:	TEMPERATURE:	BLOOD SUGAR:	
	REFERER ☐ NONE	☐ NURSE	☐ PHYSICIAN ASSISTANT	
	☐ TBA	☐ MIDWIFE	☐ DOCTOR	
	ACCOMPANYING ☐ NONE	☐ TBA	☐ MIDWIFE	☐ PHYSICIAN ASSISTANT
	☐ PARENT	☐ NURSE	☐ PARAMEDIC	☐ MIDWIFE DOCTOR
	INDICATION ☐ NO OXYGEN	☐ NO TRAINED STAFF	☐ OTHER	
	☐ NO COTS	☐ FACILITY NOT EQUIPPED		
	MODE OF ☐ PRIVATE CAR	☐ TROTRO	☐ OTHER	
	☐ TAXI	☐ AMBULANCE	☐	
DID MOTHER ACCOPANY TRANSFER	☐ YES	☐ NO	IF NO REASON	
	KMC PERFORMED DURING TRANSFER?	☐ YES	☐ NO	

EARLY CARE PRIOR TO REFERRAL

LABOUR	SKIN TO SKIN	☐ YES ☐ NO	
	BREASTFEEDING	☐ YES ☐ NO	**INTRAVENOUS FLUIDS**
	FORMULA FEEDS	☐ YES ☐ NO	IF YES, STATE WHICH MILK

ORAL GLUCOSE	☐ YES ☐ NO	CAFFEINE/AMINOPHYLLINE	☐ YES ☐ NO
ANTIBIOTICS	☐ YES ☐ NO	ROUTE OF ADMINISTRATION	☐ ORAL ☐ INTRAVENOUS

OUTCOME				
TRANSFER	☐ YES ☐ NO	DURATION OF STAY	DISCHARGED HOME	
DIED	☐ YES ☐ NO	DURATION OF STAY		

Appendix E: Ethical approvals

CCTH ethical approval

In case ofreply the reference number and the date ofthis Letter should be quoted

Our Ref.: CCTH

Your Ref.:

Dear Sir,
P. O. Box CT.1363
Cape Coast cc-071-9967 Tel: 03321-34010-14 Fax: 03321-34016
Website: www.ccthghana.ora email: info@ccthghana.com 30th July, 2021

Dr Emmanuel Okai
Department of Paediatrics
Cape Coast Teaching Hospital
Cape Coast

ETHICAL CLEARANCE - REF: CCTHERC/EC/2021 (053

The Cape Coast Teaching Hospital Ethical Review Committee (CCTHERC) has reviewed your research protocol titled, "Exploring neonatal transport practices and feasibility of implementation of Kangaroo Mother Care in neonatal transport in Ghana." which was submitted for Ethical Clearance. The ERC is glad to inform you that you have been granted provisional approval for implementation of your research protocol.

The CCTHERC requires that you submit periodic review of the protocol and a final full review to the ERC on completion of the research. The CCTHERC may observe or cause to be observed procedures and records of the research during and after implementation.

Please note that any modification of the project must be submitted to the CCTHERC for review and approval before its implementation.

You are required to report all serious adverse events related to this study to the CCTHERC within ten (10) days in writing. Also note that you are to submit a copy of your final report to the CCTHERC Office.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours sincerely

[redacted]

Prof. Ganiyu Rahman
Chairman, ERC

Sheffield Hallam University email confirming ethical approval

Status change comment
DO NOT WRITE ANYTHING IN THIS NOTES BOX AS IT CAN BE SEEN BY ALL OTHER USERS. Proceed to select the workflow status and click Done.

- Dear Emmanuel

Title of Ethics Review: Exploring neonatal transport practices and feasibility of implementation of Kangaroo Mother Care in neonatal transport in Ghana
Ethic Review ID: ER46927191

Thank you for submitting your Ethics Review on the 'Ethics Approval Sought Elsewhere UK HEI template'. This email is to confirm that the approval has been registered.

You are expected to deliver the project in accordance with the University's research ethics and integrity policies and procedureshttps://www.shu.ac.uk/research/ethics-integrity-andpractice.

As the Principal Investigator you are responsible for monitoring the project on an ongoing basis and ensuring that the approved documentation is used. The project may be audited by the University during or after its lifetime.

Should any changes to the delivery of the project be required, you are required to submit an amendment for review.

Wishing you success you with your study

Kind regards,
Ethics Research Support

*** This is an automatically generated email, please do not reply ***

Appendix F: Participant information sheet

PARTICIPANT INFORMATION LEAFLET

PROJECT TITLE: Exploring neonatal transport modalities and the feasibility of implementation of Kangaroo Mother Care in neonatal transport in Ghana

Principal investigators: Dr Emmanuel Okai, Prof. Hora Soltani, Frankie Fair
Other staff involved: Hilda Konadu Danquah (NICU nurse)
Institutions: University of Cape Coast (UCC), Cape Coast Teaching Hospital (CCTH) and Sheffield Hallam University (SHU)

Introduction: Hello, I am **Dr Emmanuel Okai**, a lecturer/researcher at UCC and SHU. I am contacting you because you are visiting this health facility, and I would appreciate it if you could participate in this project. Before you participate in this study, you must understand the following: the purpose of the study, the study procedures, benefits, risks, discomforts, and precautions, as well as your right to decline or withdraw from the study at any time. This information leaflet will help you decide if you would like to participate.

Purpose of the study: This study is being undertaken to assess the feasibility of using Kangaroo Mother Care (KMC) for the transport of preterm and low birth weight babies. We will ask questions to gather background information to help us understand the data we receive, if you consent to this study. If you are a mother, the healthcare professional who has decided to transfer your baby to the Cape Coast hospital for further care will explain what KMC is and ask if you are happy to transfer your baby to Cape Coast with that method. We will allow you to tell us how you feel about the transfer method at the end of the transfer.
Confidentiality: Information volunteered as part of this study will be treated as strictly confidential, and your identity will be protected in all circumstances.

Procedures: A set of questions will be administered after you give your consent, when you have time to answer them. The interview after the transfer will take approximately 20-40 minutes.

Potential benefits: Kangaroo Mother Care is a safe method that ensures your baby stays warm and comfortable during the journey. It will also increase the bond between you and your baby. By participating in this study, you will be helping medical personnel understand how safe and practical the process is.

Incidental medical information: If we find any incidental information, we will consult with your local physicians and provide you with the results if they will impact you or your child's health. If you do not wish to receive incidental information, we will respect your wishes and not provide you with this information.

Financial compensation/costs
There will not be financial compensation.
You will not incur any expenses from participating in this project.

Rights as a participant in the study: Participation in this study is voluntary. The decision to participate is entirely up to you. Should you decide to participate, you may withdraw from the study at any time. The care you receive now or in the future will not be affected whether you participate in or withdraw from this study.

Ethical approval: This study protocol has approval from the CCTH/College of Health Sciences human ethics committee and Sheffield Hallam University Research Ethics Committee

Contact Information: For any additional questions regarding your participation in this project, you can contact me by phone at ------ or email. If you agree to participate, please sign the consent form.
Thank you

Appendix G: Consent form

CONSENT FORM

You are invited to participate in a research study entitled "**Exploring neonatal transport practices and feasibility of implementation of Kangaroo Mother Care in neonatal transport in Ghana**." This intervention study aims to assess the feasibility and acceptability of using Kangaroo Mother Care for the transport of newly born preterm and low birth weight infants from primary and district health centres to the Cape Coast Teaching Hospital NICU, and to assess the feasibility of implementing the study in a large-scale randomised-controlled trial (RCT).
Your participation in this study is **voluntary,** and you have the right to **refuse** to participate or **withdraw** at any time. Your identity and the details of participants in this study will remain confidential in any publications or reporting of the study's results.

I confirm that I am informed of the following information

Please tick each of the following to confirm that you find it true.

□ **I acknowledge that I have read, or it has been explained to me in a language that I understand, the attached research participant information sheet.**
□ **I understand that this study is not intended to be of any direct financial benefit to me.**
□ **I understand that I am free to withdraw this authorisation and to discontinue participation in this study at any time.**
□ **I have had the opportunity to ask questions.**
□ **I confirm that I have read, or had read to me, the foregoing authorisation.**

Participant:
Name: _____ Date: _____ Signature: _____

Researcher or her representative:

Name: _____ Date: _____

Appendix H: Supplementary data for qualitative study

COREQ (COnsolidated criteria for REporting Qualitative research) checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Two authors conducted the interviews. HK and EO	9
Credentials	2	Hilda Konadu (HK): MSc Neonatal Nursing Emmanuel Okai (EO): FRCPCH, MB ChB	1, 9
Occupation	3	HK: Neonatal nurse specialist EO: Postgraduate student/Paediatrician	9
Gender	4	HK: Female EO: Male	9
Experience and training	5	HK: Previous training in qualitative methods and experience in conducting interviews EO: Attended a workshop on "how to conduct qualitative research" and "how to use NVivo software to analyse the data".	9
Relationship with participants			
Relationship established	6	Only for this research for the mothers The healthcare professionals were working colleagues	N/A
Participant's knowledge of the interviewer	7	Three of the mothers knew HK as a nurse on the neonatal unit. Four of the healthcare professionals were working colleagues of both HK and EO, and 2 were midwives who worked at a different peripheral health centre. However, all participants knew that the interview was for research purposes.	N/A
Interviewer characteristics		• HK is a specialised neonatal nurse within the unit. It is presumed that a potential power disparity with the participants may result in acquiescence bias and interviewer bias, potentially compromising data integrity. Mitigation measures employed included establishing rapport during interviews, explicitly conveying the study's purpose and assuring participants that their responses would not influence their care or their relationship with healthcare providers, and confirming that participants recognised themselves as experts on their own experiences to empower them and acknowledge the significance of their perspectives. • EO, a paediatrician in the neonatal unit, shares HK's biases, resulting in the application of similar mitigation measures. Additionally, involvement in qualitative analysis and awareness of the quantitative results from the larger feasibility study could introduce researcher bias, especially confirmation and analytic bias. To mitigate this, two other researchers conducted independent analyses, and we carefully examined discrepancies	10, 11

		between quantitative and qualitative findings during data integration.	
Domain 2: Study design			
Theoretical framework			
Methodological Orientation and Theory	9	An inductive thematic analysis was applied	10
Participant selection			
Sampling	10	Convenience sampling was used	8
Method of approach	11	Mothers and healthcare professionals willing to participate were recruited through convenience sampling, with face-to-face approaches made during the consent process for the larger feasibility study.	8
Sample size	12	16 participants, comprising 10 mothers and 6 healthcare professionals.	11
Non-participation	13	One mother was approached but declined to participate due to her urgency to leave the unit and return home	11
Setting			
Setting of data collection	14	Quiet room outside the neonatal unit, paediatric outpatients department	9
Presence of nonparticipants	15	No one else was present besides the participants and the researchers.	N/A
Description of sample	16	The essential characteristics of the samples were the mothers' age, marital status, and educational background, and, for the nurses, their years of professional experience.	11
Data collection			
Interview guide	17	A topic guide was prepared (appendices 1 & 2) and pilot-tested with three mothers and two healthcare professionals. Data from interviews conducted in the pilot test were not included in the final analysis	8,9
Repeat interviews	18	No repeat interviews were carried out.	9
Audio/visual recording	19	Interviews were audio-recorded.	9
Field notes	20	Field notes were not made during the interview. Notes made during transcription of the audio recording were used to assist in analysing the data.	9
Duration	21	Interviews lasted 20-40 minutes, with an average of 30 minutes.	9
Data saturation	22	Data saturation was discussed in the methodology section	10
Transcripts returned	23	The transcripts were not returned to participants for comment or correction.	9
Topic	**Item No.**	**Guide Questions/Description**	**Reported on Page No.**
Domain 3: analysis and findings			
Data analysis			
Number of data coders	24	Three researchers coded the data. (EO, Prince Arkoh (PA) and Evans Ntim (EN)	10

Description of the coding tree	25	The coding description is provided in the methodology section	10
Derivation of themes	26	The themes were derived from the data during analysis.	10
Software	27	Microsoft Excel sheet and NVivo 12 were used to manage the data.	10
Participant checking	28	No, participants did not provide any feedback on the findings	N/A
Reporting			
Quotations presented	29	Yes, quotations were presented and identified by the respondent's identification in the coding	12 - 16
Data and findings consistent	30	Yes, there was consistency between the data presented and the findings	12 - 16
Clarity of major themes	31	Yes, major themes were clearly presented in the findings.	12 - 16
Clarity of minor themes	32	No, there were no descriptions of the diverse cases or a discussion of minor themes presented.	N/A

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.

KMC transport mothers' interview schedule

Introduction

The interviewer will introduce themselves, thank the mother for attending, and make her feel as relaxed as possible. The interview will take place in the restroom or in one of the quiet consulting rooms in the paediatric outpatients' department at the Cape Coast Teaching Hospital.

Setting of ground rules

Explain the aim and purpose of the study.
State that issues discussed will be confidential and that nothing that is said will have any impact on the baby's care.
Explain that the interview will be tape-recorded and transcribed after the discussion.
Explain that the interview is expected to be completed within 20 to 40 minutes.
Explain to the caregiver/mother that they can stop and withdraw from the interview at any time.
Explain that each mother-baby pair has a unique study number, which will be used instead of names to ensure anonymity and confidentiality.
Explain to the caregiver/mother that they can refuse to answer any question with which they are not comfortable.
Allow the participant the opportunity to ask questions about the interview process.
Ask the caregiver/mother to sign the consent form after an explanation of the study process.

Check the tape working.

Interview prompts : This interview took place on date ----- at ------ (time) in -------- (place). It will be semi-structured and response-led. Many areas will be explored with key questions guiding the interview.

Interview questions for mothers.

1. How did you feel about being approached to be involved with the study?
2. Did you feel the time you were approached was appropriate, and you were given enough time to think it through?
3. Do you feel the study was adequately explained to you?
4. Do you feel you were given enough liberty to say no if you did not want to take part in the study?
5. What made you decide to be involved with the study?
6. How did you feel about the transport to CCTH?
7. How do you feel about using KMC for transport?
8. Do you feel the reason for the transfer of your baby was adequately explained to you?
9. How do you feel about the initial stabilisation and pretransfer process?
10. What was your experience using KMC for this transfer?
11. What is the positive aspect of the use of KMC for transfer for you?
12. Which aspects of the use of KMC were challenging for you?

13. Given the option, would you opt for KMC or the conventional means of having the baby wrapped and carried in your arms to transport your baby next time?
14. Which ways would you suggest for the improvement of this process?

After the interview

1. The researcher will record any occurrences during the interview, including the general mood of the interviewee and anything of note that happens during the interview.
2. A copy of the transcript will be offered to the interviewee, and if that is in the affirmative, the means of delivery (hospital collection or email) will be agreed upon.

Healthcare professionals interview schedule

Introduction

The interviewer will introduce themselves, thank the healthcare professional for attending, and do their best to make her feel as relaxed as possible. The interview will take place in the restroom or in one of the quiet consulting rooms in the paediatric outpatients' department at the Cape Coast Teaching Hospital.

Setting of ground rules

Explain the aim and purpose of the study.
State that issues discussed will be confidential, and that nothing said will affect the baby's care.
Explain that the interview will be tape-recorded and transcribed after the discussion.
Explain that the interview is expected to be completed within 20 to 40 minutes.
Explain to the interviewee that they can stop and withdraw from the interview at any time.
Explain that each interviewee has a unique study number, which will be used instead of names to ensure anonymity and confidentiality.
Explain to the interviewee that they can refuse to answer any question with which they are not comfortable.
Allow the interviewee the opportunity to ask questions about the interview process.
Ask the interviewee to sign the consent form after an explanation of the study process.

Check the tape working.

Interview prompts

This interview took place on date ----- at ------ (time) in -------- (place). It will be semi-structured and response-led. Several areas will be explored with key questions guiding the interview.

Interview questions

1. What is your view about the use of KMC for the transport of newborns?
2. Have you been involved in the use of KMC for caring for neonates, and for how long?
3. What do you see as the potential benefits of KMC?
4. What has been your experience with the transfer of babies to CCTH?
5. What potential problems do you envisage with the use of KMC for transport?
6. Would you recommend the use of KMC for neonatal transport?
7. In what way would you suggest that KMC can be made more acceptable to parents and nurses?
8. How do you feel nurses should be supported to use KMC for transport?

After the interview

1. The researcher will record any occurrences during the interview, including the general mood of the interviewee and anything of note that happens during the interview.
2. A copy of the transcript will be offered to the interviewee, and if that is in the affirmative, the means of delivery (hospital collection or email) will be agreed upon.

Coding themes for KMC transport mothers

Themes identified through interviews with mothers involved in KMC transport

Themes	Subthemes	Quotations
1. Perceived benefits of KMC and study involvement	i. Beneficial to both mother and baby	"I was hesitant, but then I thought it might be beneficial."
		"I thought the study could benefit my baby and me."
		"I felt the study might provide useful information for me and others."
	ii. Helping other mothers	"I felt honoured to be part of something that could help others."
		“I was happy to help because I believe in the importance of KMC."
		"At first, I was unsure, but I wanted to contribute to something meaningful."
		"I felt a little anxious, but also grateful for the opportunity."
		"I was interested in learning more and helping other mothers like me."
		"I wanted to help other mothers by sharing my experience."
		"I felt it was an important opportunity to contribute to research."
		"I wanted to support research that could improve healthcare for babies."
		"It seemed like a good way to make a difference for future mothers."
		"I wanted to learn from the process and help others at the same time."
		"I felt that my participation could help improve care for newborns."
	iii. Trust and respect	"I felt supported, knowing that people cared about my experience."
		"It made me feel important, like my opinion mattered."
		"I trusted the team and felt comfortable participating."

Themes	Subthemes	Quotations
2. KMC for transport	i. Comforting and secure	"The transport was convenient and made things easier for me. I appreciated having to choose my transport; it was a big help."
		"The transport was comfortable, and I felt safe travelling to CCTH."
		"I felt more at ease with the transport; it was one less thing to worry about. Having to choose my own transport was thoughtful and very helpful for me.
		"I think using KMC for transport is comforting for the baby. It was a good experience, as KMC made the trip smoother for both of us."
		"I felt that KMC kept my baby calm and comfortable throughout the journey."
		"The KMC method made the transfer smoother for both of us."
		"I found KMC comforting; it reassured me that my baby was safe. It was a great way to provide comfort and stability for my baby."
		. "It was reassuring to use KMC, especially while travelling. I would choose KMC again because it feels more comforting."
	ii. Security	"I felt that KMC made my baby feel secure during the journey."
		"I felt KMC was a good way to protect my baby while moving around." Using KMC for transport felt natural and safe."
		"I felt that KMC made my baby feel secure during the journey. KMC during transport gave me confidence that my baby was safe."
		"It was a positive experience; KMC helped keep my baby warm and secure."
		"Using KMC gave me peace of mind that my baby was safe with me. It allowed me to keep my baby close, which felt very comforting."
		"KMC helped my baby feel safe and secure during the transfer."
		"Using KMC kept my baby warm and protected from the outside environment. I'd opt for KMC travel again because it kept my baby calm and secure."

Themes	Subthemes	Quotations
	iii. Empowering	"Given the choice, I'd opt for KMC because it felt empowering."
		"I'd choose KMC; it made the journey more positive for both of us."
		"KMC made me feel empowered as a mother, knowing I was doing my best." It turned the transfer into a more positive experience for both of us."
		"I appreciated how KMC reduced my baby's stress during the transfer."
		"I felt more in control of my baby's care during the transfer."
		"KMC helped reduce my baby's anxiety and stress during the journey."
		'' It was scary at first seeing the size of my baby, but using KMC during the journey made me confident I can look after her"
	iv. Bonding	"Using KMC helped keep my baby calm and close to me."
		"I felt more connected to my baby by using KMC while travelling."
		"Using KMC during the transfer made me feel close to my baby."
		"I felt more connected to my baby and less anxious using KMC."
		"Using KMC felt natural and allowed me to monitor my baby closely.
		"It made it easier for me to bond with my baby while travelling."
		"I appreciated that I could monitor my baby's condition closely."
		'' I will choose KMC again as it helped me bond with my baby during the transfer."
3. Challenges and solutions	i. Maternal anxiety	"I worried about my baby's safety while trying to balance them in KMC."
		"I felt anxious about not being able to see my baby's face clearly.
		"Sometimes I felt unsure if I was doing KMC correctly. "
		"I was concerned about the weather conditions affecting my baby while using KMC."

Themes	Subthemes	Quotations
	ii. Comfort and safety during the journey	"It was challenging to hold my baby for a long time during the transfer.”
		"It was hard to adjust my clothing and keep everything secure."
		"Carrying my baby in KMC made it difficult to move around easily. "
		I found it tiring to hold my baby, especially during a longer journey."
		"It was difficult to manage other items I needed while using KMC."
		"I had to find a comfortable position that worked for both of us."
	iii. Training and supportive healthcare staff	"Provide more training for mothers on how to properly use KMC."
		"Increase support from healthcare staff during the transfer.”
		"Offer comfortable wraps or carriers specifically designed for KMC.”
		"Create a checklist for mothers to ensure they have everything needed for KMC."
		"Provide information sessions about the benefits and techniques of KMC.”
		"Ensure that transportation is easily accessible and convenient for all families.”
		"Offer additional emotional support during the transfer process."
		"Improve communication about what to expect during the transfer."
		"Ensure that the environment during transfer is calm and safe for both mother and baby.”
		"Gather feedback from mothers after each transfer to identify specific areas for improvement."

Coding themes for healthcare professionals.

Themes identified through interviews with healthcare professionals.

Themes	Subthemes	Quotations
1. Perceived benefits of KMC and study involvement	i. Beneficial to both mother and baby.	''KMC during transport is highly beneficial and addresses the issue of temperature regulation for the baby due to lack of equipment.''
		''KMC helps in regulating the baby's temperature, which is crucial during transport. Additionally, it fosters bonding between the mother and the baby.''
		''KMC for transporting newborns helps maintain the baby's temperature in situations where environmental factors, such as air conditioning in ambulances, could otherwise be harmful.''
		''KMC transport of newborns is important to help maintain the baby's temperature and reduce separation between babies and parents.''
		''Fostering bonding between the baby and the caregiver. This bonding extends to other family members, such as the grandmother or father, who can also participate in KMC if the mother is unavailable. This flexibility in caregiving strengthens the emotional connection between the baby and family members. ''
		''Observed that babies who undergo KMC for extended periods, typically two to four hours, show noticeable improvements in growth and weight gain. ''
		''A significant benefit is the reduction in hospital stay, as the continuous care provided by the mother through KMC effectively substitutes for the functions of incubators and other machines.''

Themes	Subthemes	Quotations
2. KMC for transport	i. Comfort and security	"KMC saves the lives of babies during transportation by providing better protection than simply wrapping them, which exposes them to harmful atmospheric conditions."
		''The nurses here are very welcoming and supportive when babies are transferred using KMC. It's been so good to be involved in KMC. ''
		The CCTH staff consistently encourage the use of KMC, expressing happiness and support when babies are brought in using this method. This has given us a positive experience.''
		''Lack of ambulances. As a result, commercial vehicles like taxis are often used, which are not adequately equipped for transporting newborns. Often leads to babies arriving at the hospital hypothermic. However, implementing KMC during transport has demonstrated positive results."
		''KMC is considered a simple and effective method for stabilising newborns during transport.''
		"The mothers have been keen to engage in KMC transport and have been happy with how it keeps their babies close during the transfer."
	ii. Bonding	"The challenge of not having ambulances has not really been a challenge with KMC transport, as the mothers are happy to be in the commercial vehicles with their babies close to them."
		''KMC strengthens the bond between mother and child, ensuring the baby remains attached and nurtured by maternal love. It also offers essential support for weak or premature babies, giving them a better chance of survival. ''
		''Offers several key benefits, including fostering bonding between the mother and baby, helping babies regulate their temperature. ''
		''One of the key advantages is the promotion of bonding between the mother or caregiver and the baby, which is essential for emotional and psychological development.''

Themes	Subthemes	Quotations
3.Challenges and solutions		''There should be community sensitisation programs to educate the public about its benefits and address any misconceptions. Mothers often feel uncomfortable or hesitant about performing KMC, even after being informed of its benefits, which requires extra effort from healthcare providers to convince them.'' ''Performing KMC in public transport can lead to stigmatisation, as people may stare or react negatively. To address these issues, having specialised transport specifically for cases requiring KMC would be beneficial, ensuring smoother and more dignified transfers to healthcare facilities.'' ''It should be incorporated into the education provided during antenatal visits. Expectant mothers need to be informed about KMC before delivery, particularly in cases where there might be a preterm birth. There should be ongoing support and education to parents and the immediate family members throughout the pregnancy to make KMC more acceptable and well-understood.'' ''Visual and tangible support, such as banners showing success stories of mothers who used KMC transport, can help encourage parents to adopt the method. By seeing real-life examples of babies who survived through KMC transport, parents may be more inclined to use it.'' ''It is important to address the gap between awareness and practical knowledge. Many nurses have heard of KMC but lack hands-on experience. Providing educational materials, such as flyers or pamphlets that demonstrate the procedure and outline its benefits, can be very helpful.'' ''A dedicated transport system, possibly by recruiting and training the local commercial transport operators, should be established. '' ''Providing the necessary materials and motivation for nurses would help during the transfer process, especially when there are no family members to accompany the baby. To support nurses in using KMC for transport, it is important to address the gap between awareness and practical knowledge. Many nurses have heard of KMC but lack hands-on experience. Providing educational materials, such as flyers or pamphlets that demonstrate the procedure and outline its benefits, can be very helpful.''

''External support from the government, larger healthcare facilities, and NGOs. Organising training sessions or outreaches by health workers from these larger facilities can ease the implementation of KMC, especially in peripheral areas. Adequate items and supplies should be provided to facilitate the process, and there should be motivation for nurses to perform KMC even in challenging situations.''

Appendix I: Supplementary data for the conventional care cohort

Conventional care mothers' interview schedule

Introduction

The interviewer will introduce themselves, thank the mother for attending, and make her feel as relaxed as possible. The interview will take place in the restroom or in one of the quiet consulting rooms in the paediatric outpatients' department at the Cape Coast Teaching Hospital.

Setting of ground rules

Explain the aim and purpose of the study.
State that issues discussed will be confidential and that nothing that is said will have any impact on the care of the baby
Explain that the interview will be tape-recorded and transcribed after the discussion.
Explain that the interview is expected to be completed within 20 to 40 minutes.
Explain to the caregiver/mother that they can stop and withdraw from the interview at any time.
Explain that each mother-baby pair has a unique study number, which will be used instead of names to ensure anonymity and confidentiality.
Explain to the caregiver/mother that they can refuse to answer any question they are not comfortable with.
Allow the participant the opportunity to ask questions about the interview process.
Ask the caregiver/mother to sign the consent form after an explanation of the study process.

Check the tape working.

Interview prompts : This interview took place on date ----- at ------ (time) in -------- (place). It will be semi-structured and response-led. Many areas will be explored with key questions guiding the interview.

Interview questions for mothers in the conventional care cohort

1. How did you feel about being approached to be involved with the study?
2. Did you feel the time you were approached was appropriate, and you were given enough time to think it through?
3. Do you feel the study was adequately explained to you?
4. Do you feel you were given enough liberty to say no if you did not want to take part in the study?
5. What made you decide to be involved with the study
6. How did you feel about the transport to CCTH?
7. How would you feel about the initial stabilisation of your baby before transfer?
8. Do you feel the health workers adequately explained the reason for the transfer?
9. How do you feel the transfer process can be improved
10. What do you think about the care of your baby on arrival in CCTH

After the interview

1- The researcher will record any occurrences during the interview, including the general mood of the interviewee and anything of note that happens during the interview.
2- A copy of the transcript will be offered to the interviewee, and if that is in the affirmative, the means of delivery (hospital collection or email) will be agreed upon.

Coding themes for conventional care mothers

Themes identified through interviews with mothers involved in conventional care transport.

Themes	Subthemes	Quotations
1. Systemic challenges in neonatal transfer.	i. Financial	“Everything was fine on the journey. We came in a taxi. Aside from the financial situation, everything was okay.”
		“We couldn't afford the ambulance, so we arrived in a friend's car. I'd say everything's fine.“
	ii. Poor transport system	“The road is not tarred for some part of the journey, so it's a bit bumpy. There were no ambulances. My uncle drove us in his taxi. Maybe having an ambulance would have helped because of the road''
		“Everything was fine on the journey. I came with my auntie in a taxi. As there were no ambulances.”
		''It would be helpful if we could be given an ambulance and a nurse to come with us.''
		"If a nurse is available, maybe they can come with us because the baby is small and we were all worried about him during the journey.''
2. Opportunities for enhancing inpatient neonatal care	i. Communication	“I would say everything was fine. Except for the night nurses, they provided no explanations, so they have to improve on that.”
		"We found the staff’s reception, especially from 'Auntie Corny', to be warm and comforting. We were satisfied with the service, but I feel the nurses have to talk to us more because we worry a lot, especially because the baby is small.''
		''We are happy with the service. The place is a bit small and can get hot. We would also like to learn more about the babies from the doctors and nurses more frequently.''

Appendix J: KMC poster

Appendix K: Snapshots from the Director of Studies and the supervisor's visit to study sites.