THE ROLE OF HEALTH FACILITIES IN WOMEN'S USE OF MATERNAL AND NEWBORN POSTNATAL CARE IN MALAWI

Eunsoo Timothy Kim

A dissertation submitted to the faculty at the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Maternal and Child Health in the Gillings School of Global Public Health.

Chapel Hill
2019

Approved by:

Kavita Singh

Ilene Speizer

Gustavo Angeles

Kirsten Kainz

Guang Guo

ABSTRACT

Eunsoo Timothy Kim: The Role of Health Facilities in Women's Use of Maternal and Newborn Postnatal Care in Malawi
(Under the direction of Kavita Singh)

The postnatal period is a vulnerable time for both the mothers and the newborns. Receiving timely and quality postnatal care during this period can be important for their survival. The objective of this dissertation was to examine how health facilities play a role in women's use of maternal and newborn postnatal care in Malawi.

In the first paper, it was found that the majority of rural Malawian women lived within 10 km of a health facility that provided postnatal care services. Having a clinic-level facility providing postnatal care services was not found to be significantly associated with maternal and newborn postnatal care in most cases. Because clinic-level facilities and health centers should be at the forefront of providing primary healthcare services, these facilities should all be supported to provide quality preventative postnatal care services. In addition, raising community awareness about the importance of timely postnatal care would be important.

In the second paper, it was found that less than half of women who deliver in facilities received maternal postnatal check before facility discharge. A little over two-thirds received newborn postnatal check before discharge. Considering that most women deliver in government-operated hospitals or health centers in Malawi, these facilities should be targeted for intervention. Compared to delivering in government hospitals, delivering in private hospitals had higher effects on maternal and newborn postnatal care before discharge. Receipt of cesarean

section had higher effects as well. It is important for health facilities to revisit their protocols for providing postnatal care. Task-shifting to lower-level health workers may also be necessary. The objective is to have all women and newborns delivering at the facilities receive postnatal care before they are discharged.

In conclusion, there is much work to be done until all delivering women and their newborns benefit from timely and quality postnatal care services, regardless of their place of delivery. This dissertation contributes to the existing literature by offering important insights about the current state of postnatal care provision in Malawi and bringing more understanding about the role of health facilities in postnatal care use.

To Jesus Christ, my Lord, Savior, Light, Helper, Friend and Lover.
Thank You for offering Your eternal life, forgiveness of sins, resurrection, faithfulness, friendship, love, joy, peace, rest, guidance, grace, mercy and communion to any and all who receive and believe in Your Name. My life would be meaningless without Your Presence. You are and will always be my life's utmost purpose and desire.

For God so loved the world that He gave His only begotten Son Jesus, that whoever believes in Him should not perish but have everlasting life. John 3:16

"I (Jesus) am the light of the world. He who follows Me shall not walk in darkness but have the light of life." John 8:12

Whoever calls on the name of the Lord Jesus shall be saved.
Romans 10:13 Acts 2:21 Joel 2:32

Blessed and holy is he who has part in the first resurrection.
Over such the second death has no power, but they shall be priests of God and of Jesus Christ, and shall reign with Him a thousand years. Revelation 20:6

ACKNOWLEDGEMENTS

There are many people who have supported me in reaching this academic milestone. I would like to mention all of them by name and thank them personally. To Dr. Kavita Singh, my academic advisor, thank you very much for mentoring me and always giving me opportunities to participate in your projects as a research assistant. From the very start to the finish, your technical knowledge, professionalism, coaching, mentoring, and kindness have always been a source of inspiration for me. I have also appreciated your flexibility in work, prioritizing my personal work-life balance and securing funding for me every semester. To Dr. Ilene Speizer, thank you very much for always going the extra mile in reviewing my papers and also in my job search. I have often been inspired by your professionalism and style of mentoring. I have learned a lot from working with you. To both Dr. Kavita and Dr. Ilene, your time and commitment in my professional growth were very appreciated. To Dr. Gustavo Angeles, thank you for providing much needed feedback on my methods. I have always been inspired by your depth of methodological knowledge and clarity in explaining statistical concepts. To Dr. Kirsten Kainz and Dr. Guang Guo, thank you for your constructive feedback on my papers. They were very helpful. To Dr. Cathy Zimmer, thank you for providing methodological feedback on my structural equation model in paper 2. To Dr. Myung Lee, thank you for giving me ample opportunities to learn what global health looks like in the field. I have learned a lot from working with you. I really appreciate all of the support and care you showed me both personally and professionally. Your support was what propelled me to pursue further studies in graduate school. To Dr. Karl Umble, thank you for serving as my undergraduate senior honors thesis advisor. My

desire to learn more about research and evaluation stemmed from working with you. Your leadership and style of coaching were what I needed at the moment to gain confidence as an aspiring researcher.

I would also like to thank my family and friends for their support. Noah Coleman, Chris and Lucy Spargo, Mike Pham, Eva Zarzar, Deanna Drescher, Elizabeth and Tavitris Bracey, Carol Loebs and Niko Peele and Jean Ahn, thank you for your close friendship, joy-filled fellowship, encouragement and support in more ways than one. You guys are some of the best friends I have ever had. Sharon and Nelson Pierce, Pamela Ransohoff, Carol Ellis and Tracy Murillo, thank you always for sharing your wisdom, prayers and encouragement. I really appreciate and value your friendship. Matthew and Sarah Bollinger, thank you for your care, encouragement and prayers. Donna Loebs, thank you so much for taking care of my son, Hankyul Zionel Kim. I would not have been able to finish my dissertation and graduate on time if it were not for your help. Elizabeth Bracey, thank you also for taking care of Hankyul Zionel Kim with Donna. Sohyun Kim, thank you for always keeping in touch with me and sharing valuable insights you learned from the field. Your friendship is very encouraging to me. Sunwoo Kim, thank you for teaching me how to be a great practitioner in global health. I have learned a lot from working with you. Thank you also for keeping me in your prayers. Seongcho Park, thank you for your kindness and hospitality that you have shown me every time I visited Malawi. Your friendship made my stay in Malawi something to look forward to. Wonhwa Kang and Sujung Park, thank you also for your hospitality and kindness while I was in Malawi. I really enjoyed spending time with your family and the church community.

To my parents, Young Seo Kim and Esther Jiyoung Kim, thank you very much for always believing in me and supporting me with your love, faith, hope, kindness, wisdom, prayers

and encouragement. Your testimonies are a true witness to God's faithfulness, goodness and grace. I honor the sacrifices you both have made for me to come this far. To my sister, Koheun Rebekah Kim, thank you for being the sister that I need and have always wanted. You encourage me in more ways than you know. To my father-in-law, Taewoong Park, and my mother-in-law, Hyejung Jang, thank you so much for your understanding, wisdom, patience, prayers and encouragement. I honor you both for your faithfulness, service and testimony in the Lord. To my grandparents in Masan, Ki Hyun Kim and In Sung Lee, thank you for your continuous thoughts and prayers. I am grateful for the amazing spiritual heritage that you are leaving behind for all of us. To my grandmother in Delaware, Keum Ja Yoo, thank you for the sweet memories, thoughts and prayers. It comforts me to know that you are always praying for us. To my loving wife, Jieun Esther Park, thank you always for your love, grace, mercy, gentleness, patience, care and encouragement. Your Christ-like character inspires me and makes me want to pursue Jesus more every day. Your companionship and trust have enabled me to keep going. I know that I am blessed because you are by my side. To Hankyul Zionel Kim, my newborn son, and my future child(ren) who are not yet born in this world, thank you and love you always.

Lastly, a part of this dissertation was carried out with support provided by the United States Agency for International Development (USAID) through MEASURE Evaluation (cooperative agreement AID–OAA–L–14–00004). The views expressed are not necessarily those of USAID or the United States government.

PREFACE

Before reading the dissertation, I want to preface the work by explaining how I chose Malawi as my geographic focus. Through my research assistantship with Dr. Kavita Singh and Dr. Ilene Speizer, I had an opportunity to visit Malawi for the first time in 2015. During this time, I was tasked with creating an EPI INFO database, collecting patient survey data, monitoring maternal and newborn health indicator data and connecting with health providers and staff to get a general sense of the health care system in Malawi. Since then, I was able to travel to Malawi again in 2016 and another time in 2017 for continuous data collection and monitoring. The collected data were later used for evaluating a project that aimed to improve maternal and newborn health outcomes by constructing maternity waiting homes near health facilities.

During my travels, I was able to see the workings of the health care system firsthand. I was also able to talk with many providers and staff at health facilities of various sizes and types including a small clinic/dispensary, a mid-sized health center and a larger district hospital. Looking at their facility-level maternal and newborn indicators and listening to the providers' narratives inspired me to focus my dissertation work on saving maternal and newborn lives around the time of birth in Malawian context. Particularly, I became interested in the postnatal period because I saw that a lot of work needed to be done with increasing the use of postnatal care. Hence, I would like to inform the readers that my findings here were discussed and interpreted in light of other evidence in the literature as well as my firsthand account of the Malawian health care system.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

HSSP II	Health Sector Strategic Plan II
MMR	Maternal Mortality Ratio
WHO	World Health Organization
PNC	Postnatal Care
SDG	Sustainable Development Goal
DHS	Demographic and Health Survey
MDHS	Malawi Demographic and Health Survey
SPA	Service Provision Assessment
MSPA	Malawi Service Provision Assessment
GEE	Generalized Estimating Equations
CHAM	Christian Health Association of Malawi
BLM	Banja La Mtsogolo Clinics
NGO	Non-governmental Organization

CHAPTER 1. BACKGROUND

Malawi: Health Sector Objectives

Malawi is a landlocked country located in the Southeastern part of the African continent (1). It borders Mozambique to the south, Zambia to the west and Tanzania to the north (1). The population is estimated at about 18 million in 2016 (1) and the majority live in rural areas (2). Although Malawi has made important social and economic strides in the recent past (1), it is still vulnerable to instability due to high levels of poverty, limited options for economic activities, political corruption, low infrastructure development, lack of technology adoption, widespread shortage of energy and health challenges such as high maternal and newborn mortality (1).

In the health sector, the government of Malawi has updated its strategic goals and guidelines in 2017 to extend until 2022 (3). The HSSP II, which followed the strategic plan that was in effect between 2011 and 2016, aims to establish universal health coverage that ensures quality of care, equitable care and affordability of care for the population in need (3). Specifically, it outlines eight objectives to achieve by 2022 (3). They are broadly related to ensuring universal and equitable access to quality health care, reducing environmental, social and behavioral risks to health, improving the availability and quality of health care facilities and medicines, addressing concerns pertaining to human resources for health, reforming the health information system, improving the governance structure at all levels of the health system and increasing resources for efficient health financing (3).

Among the key objectives outlined in the HSSP II, the dissertation primarily focuses on the government's initiative to improve the availability and quality of health care services at facilities.

Figure 1. Map of Malawi (From the MDHS 2015-16 Final Report) (2)

Trends in Maternal Mortality

The MMR which is defined as the number of maternal deaths per 100,000 live births, has decreased significantly in sub-Saharan Africa from 1990 to 2015, going from 987 maternal deaths per 100,000 live births to 546 maternal deaths per 100,000 live births (4). This is a 45 percent decrease in the MMR between the two time periods (4). Despite the significant decrease, the 2015 MMR in sub-Saharan Africa was the largest among all MMRs of other world regions (4).

Similar to the overall MMR trend in sub-Saharan Africa, the MMR in Malawi also decreased notably from 957 maternal deaths per 100,000 live births in 1990 to 634 maternal deaths per 100,000 live births in 2015 (5). However, this only represents a 34 percent decrease between the two time periods which is lower than the 45 percent decrease in MMR in the region (5). This calls for more focused policy and programmatic strategies to reduce maternal mortality in Malawi.

Trends in Neonatal Mortality

Neonatal mortality, according to the WHO, is defined as deaths occurring in the neonatal period which is the first 28 days of life after birth (6). Neonatal mortality can be further differentiated into early neonatal deaths and late neonatal deaths (6). Early neonatal deaths refer to deaths occurring in the first seven days of life after birth and subsequently, late neonatal deaths refer to deaths occurring between the seventh day and the 28^{th} day of life after birth (6). Globally in 2015, 1 million newborns died on the first day of life after birth and nearly 2 million died in the first seven days of life which are an alarming statistics (7).

In developing countries, the number of neonatal deaths steadily declined from 4,990,000 deaths in 1990 to 2,639,000 deaths in 2015 (8). The neonatal mortality rate in 2015 in sub-Saharan Africa was 29 deaths per 1,000 live births (8). Despite the dramatic reduction in neonatal deaths over the years, the rate of reduction is slower than that of under-five deaths (8). From 1990 to 2015, the share of neonatal deaths among under-five deaths in sub-Saharan Africa actually increased by 36 percent (8).

In Malawi specifically, the share of neonatal mortality in under-5 mortality increased from approximately 20 percent in 1990 to 35 percent in 2015, which represents about 75 percent increase in the share of neonatal mortality among under-5 mortality in the specified time period (8). This renders Malawi an important country in sub-Saharan Africa to study neonatal mortality.

PNC in Reducing Maternal Mortality

A systematic analysis of the global causes of maternal death between 2003 and 2009 found that over a half of all maternal deaths were attributed to hemorrhage (27.1%), hypertensive disorders (14.0%) and sepsis (10.7%) (9). Among causes related to hemorrhage, postpartum hemorrhage made up the majority of cases with 19.7% (9). In sub-Saharan Africa, 24.5% of causes are attributed to hemorrhage and 15.2% are attributed specifically to postpartum hemorrhage (9). The first 24 hours after delivery is especially a vulnerable period for mothers' survival, requiring timely and skilled follow-up PNC in order to minimize preventable deaths (10,11).

PNC in Reducing Neonatal Mortality

It is estimated that two-thirds of all newborn deaths are preventable by effective implementation of known interventions around the time of birth and in the first seven days of life after birth, a critical window for newborn survival (12).

Life-saving interventions for newborns include essential newborn care components at the time of birth and timely and adequate postnatal check-ups following birth (12). Skin-to-skin care between the mother and the newborn, resuscitation of the newborn, delayed bathing, immediate drying and wrapping of the newborn, hygienic cord care and immediate breastfeeding are among the essential newborn care components at the time of birth (13). Following birth, timely and adequate PNC follow-up visits are expected to improve the chance of early detection and management of illnesses to maximize newborn survival (11).

Global PNC Recommendations

Current WHO recommendations for PNC slightly differ based on the location of delivery. For births occurring in health facilities, mothers and newborns are recommended to receive proper care during the first 24 hours (13). For births occurring in home settings, making the first postnatal visit as soon as possible within the first day of birth (24 hours) is recommended (13). Regardless of the place of birth, three follow-up postnatal visits are recommended: on the third day, between the first and the second week and at 6 weeks (13). These recommendations, however, exist to serve more as guidelines for countries to adopt than strict rules to follow. Countries are expected to tailor these general guidelines to their specific needs and availability of resources (10).

During the first 24 hours after birth, it is paramount that mothers and newborns are properly assessed for danger signs such as hemorrhage, uterine contraction and fever for mothers and difficulties with feeding or breathing, lack of movement, hyperthermia, hypothermia and jaundice for newborns (14). For postnatal contacts after the first 24 hours, mothers should be continually assessed for danger signs, nutritional status, pain levels and depression symptoms among others (14). Newborns should also be continually assessed for aforementioned danger signs as well as proper breastfeeding at additional postnatal visits (14).

A study that pooled recent DHS data from 10 different African countries found that regardless of the skill level of the provider, newborns receiving PNC by day 7 had lower probability of death between days 2 and 7 and also between days 2 and 28 compared to those who did not receive any PNC by day 7 (15). This study highlights that timely PNC provided by unskilled and skilled health workers alike was associated with the reduction in the probability of newborn death (15), lending support to the recommendations set forth by the WHO.

Determinants of Maternal PNC

Several studies in the literature have examined the association between individual-level predictors and the utilization of maternal PNC in sub-Saharan Africa. For example, a study of the determinants of maternal health service utilization in Ethiopia found that individual factors such as urban residence, not ever having been married, orthodox and protestant Christian faith, higher education status, higher household wealth status, having a parity of one compared to five or more, higher levels of husband's education, women's autonomy to make healthcare decisions for themselves and use of antenatal care during pregnancy were positively associated with use of women's PNC within 42 days after delivery (16).

Another study in Nigeria examined determinants of PNC non-utilization among women. This study found that higher mother's age at birth, whether the pregnancy was wanted later, higher women's education status, greater household wealth status, use of antenatal care, distance to health facility not being a big problem in accessing care and not delivering at a health facility had lower odds of PNC non-utilization (17). Factors such as religious faith, region and greater birth order had higher odds of PNC non-utilization (17).

In a study conducted in rural Lilongwe, Malawi, not using local sources of care at home after delivery in lieu of PNC, women's satisfaction with health workforce performance during delivery and postnatal service, receiving health education before mothers' postnatal discharge, delivering at the health facility, having high family income and not having complications during delivery were associated with maternal PNC use within the first 6 weeks after delivery (18).

Going beyond just looking at individual-level predictors, a few studies in the literature used a multilevel analysis method to examine both the individual-level predictors and community-level predictors simultaneously. A study in rural Tanzania examined the determinants of maternal PNC at health facilities using a multilevel analysis method (19). The results showed that at the individual level, having a primary education or higher, going through cesarean delivery, being counseled for PNC by community health workers and having received HIV testing for the infant and the partner were associated with greater odds of maternal PNC use within the first 6 weeks of delivery while having severe antenatal swelling of face and legs and delivering either in a hospital, health center or dispensary compared to delivering at home were associated with lower odds of maternal PNC use within the first 6 weeks of delivery (19).

At the community level, high community prevalence of postpartum contraceptive use and high levels of community trust in the health system on maternal health-related services were associated with greater odds of maternal PNC use (19). Interestingly, this study did not find community levels of education, community levels of poverty and distance to the nearest health facility (facility within the village, facility within 0 – 5 km, facility located more than 5 kilometers away) to be associated with maternal PNC use (19).

A study in Nigeria that examined individual-, household- and community-level predictors for maternal health services found that education, age at birth, ethnicity, family planning approval and reporting of ideal family size significantly predicted PNC at the individual level (20). Socioeconomic status significantly predicted PNC at the household level (20). Residence in urban areas and level of community exposure to media such as TV and radio significantly predicted PNC at the community level (20).

Another study in Nigeria using multilevel analysis found that higher levels of education, having formal employment, greater household wealth and higher community levels of health facility delivery significantly predicted PNC use while having a large household size of 5 or more members had significantly lower odds of PNC use (21). Religious faith, ethnicity, region of residence and interactions between community levels of women's education and ethnicity were also found statistically significant in predicting PNC use (21).

Finally, a study in Northwest Ethiopia using multilevel analysis found that individual preference for skilled maternity care, having had at least one antenatal visit in prior pregnancies and residence in communities in which source of income comes from farming and trading

compared to only farming significantly predicted PNC use by skilled providers (22). Average distance to the nearest health center was not a significant predictor in the study however (22).

Determinants of Newborn PNC

To the researcher's knowledge, only one study examined newborn PNC as the study outcome in sub-Saharan settings. A study in Nigeria looking at the determinants of antenatal care, institutional delivery and newborn PNC found that mother's age, place of administrative geopolitical areas, urban or rural residence, levels of education for both the mother and the husband, wealth, parity, whether the pregnancy was wanted, compliance with four or more antenatal visits, delivery at the health facility and status in the household as the decision maker predicted newborn PNC (23). Notably, high levels of wealth, high levels of education for both the mother and the husband and living in an urban area were positively associated with newborn PNC while higher parity was associated with lower odds of newborn PNC (23).

Motivations for the First Paper

Building on prior research evidence and the need for continued attention on PNC, the dissertation focuses on two topics of relevance in Malawian context. The first paper examines how the availability of health facilities around household communities or clusters is associated with maternal and newborn PNC, which is different than the conventional approach of using distance to the nearest health facility as an indicator. There is some evidence in the literature that women often bypass the nearest health facilities to seek delivery care at more distant facilities that are perceived to offer higher quality of care (24–27). For example, a study in rural Tanzania found that over 40% of women bypassed their nearest primary clinics in order to deliver at higher-level health facilities such as health centers and hospitals (26). In addition, the study

found that women who bypassed were more likely to be checked before discharge from the facility and were more likely to report higher ratings for quality of care provided (26). Those who bypassed were also more likely to report higher ratings for satisfaction despite having to travel greater distances and paying higher overall costs (26). For these reasons, this study assumes that women generally perceive higher-level health facilities to provide greater quality services than lower-level health facilities such as primary clinics. This assumption is also supported by other studies in the literature (28–30).

These studies challenge the notion that women will always utilize the facilities that are nearest to them due to the convenience of traveling less distance, rendering distance to the nearest health facility an inefficient predictor for delivery care. Although utilizing skilled care for delivery is fundamentally different in nature than PNC which has a more preventative aspect, it would be logical to assume that women would still prefer health facilities that provide high quality of care and are closest to their residence for pregnancy-related care. Cronin, Guilkey and Speizer lend support for this assumption that women prefer health facilities that are perceived to have high quality and are close by, albeit the study was done with a focus on family planning use in an urban setting in Senegal (24). Even though their research is most applicable to urban areas, this study posits that women in rural areas will exhibit similar facility choice preferences given the necessary resources. By examining the effects of different types of health facilities at varying distances from household clusters, we can see if Malawian women do prefer health centers and hospitals over clinic-level facilities for PNC.

Motivations for the Second Paper

A number of studies in the past have looked at determinants of PNC (16,18–22,31). However, most of these studies have used PNC within a certain time period as the outcome without making a distinction between PNC before discharge and PNC after discharge for women delivering at health facilities (16,18–22,31). This is an important distinction to make because conceptually and practically, factors associated with PNC before discharge should have less to do with women's personal preferences and choices. Rather, it should have more to do with the care environment. The second paper makes this distinction by specifically focusing on receipt of maternal and newborn PNC before facility discharge. In addition, the receipt of cesarean section, an indicator for high-risk deliveries, was included as a mediator to see if there are indirect effects on maternal and newborn PNC before facility discharge. Depending on the type of health facility where women delivered and received cesarean section, protocols and practices regarding PNC may vary.

Theoretical Framework: The Three Delays Model

The Three Delays Model outlines three stages of delay in receiving adequate treatment for women in emergency obstetric conditions (32). Although the original focus of the model was on emergency situations (32), the model can be applied to the process of seeking facility-level preventative healthcare services in general (33). The first phase consists of individual- and family-level delays in the decision to seek care: unfavorable relationship dynamics in the family, low status of women in the household, lack of knowledge and concerns about risks during pregnancy, high costs related to seeking care, unsatisfactory previous experience and low perceived quality of healthcare services (32). The second phase consists of delays in reaching a

health facility capable of providing adequate care: the limited number and distribution of accessible health facilities, significant traveling time to the facility, inadequate means of transportation and lack of road infrastructure (32). The third and final phase consists of delays in receiving quality care after reaching the facility: inappropriate referral system, inadequate stock of supplies, medicines and equipment and insufficient number of trained health personnel (32).

Focusing on the availability of health facilities providing PNC in the first paper addresses the second stage of the Three Delays Model (32). Even with knowledge or determination to pursue facility-based care, the lack of health facilities that are available to provide quality PNC can be a reason for delay. The second paper also aligns with this model (32) because receipt of PNC before facility discharge depends on factors pertaining to the health system and the facilities which are outside of women's control. As facility delivery continues to rise in Malawi (2) and barriers to quality PNC potentially exist in all "three phases", a proper assessment of the current situation is warranted. As shown in Figure 2 below, the dissertation addresses elements pertaining to both phase 2 and phase 3 of the Three Delays Model.

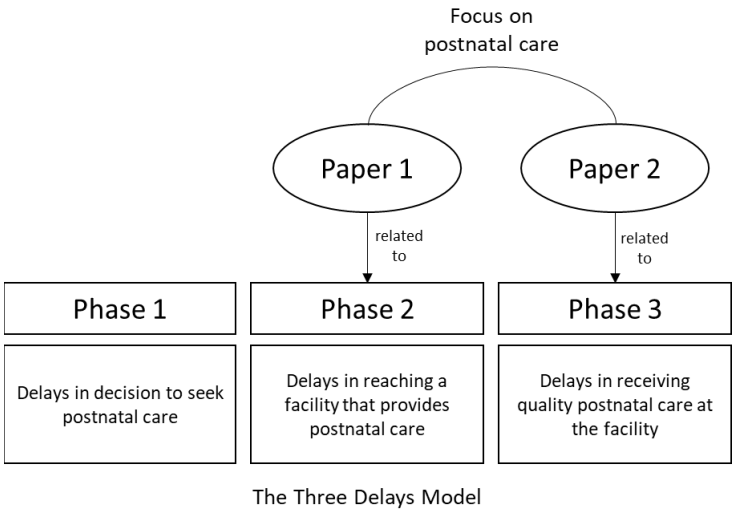


Figure 2. Application of the Three Delays Model for PNC

Research Questions

Title of The First Paper: Availability of health facilities and utilization of maternal and newborn PNC in rural Malawi.

Question 1. What is the availability of health facilities providing PNC in rural Malawi?

Question 2. Where and when do mothers and newborns receive PNC in rural Malawi?

Question 3. What are the effects of having different types of health facilities at varying distances from household clusters on receipt of maternal and newborn PNC in rural Malawi?

Title of The Second Paper: Influences of health facility type for delivery and experience of cesarean section on maternal and newborn PNC before facility discharge in Malawi.

Question 1. What are the direct effects of delivering in different types of health facilities on maternal and newborn PNC before facility discharge in Malawi?

Question 2. What are the indirect effects of delivering in different types of health facilities on maternal and newborn PNC before facility discharge? Receipt of cesarean section is examined as a mediator between type of delivering health facility and maternal and newborn postnatal care before facility discharge.

Question 3. What are the direct effects of cesarean section and other maternal and newborn characteristics such as age, education, number of births, newborn size, residence and region on maternal and newborn PNC before facility discharge?

CHAPTER 2. AVAILABILITY OF HEALTH FACILITIES AND UTILIZATION OF MATERNAL AND NEWBORN PNC IN RURAL MALAWI

Introduction

Two of the targets for SDG 3 are to universally reduce the MMR to less than 70 maternal deaths per 100,000 live births and neonatal mortality to at least as low as 12 neonatal deaths per 1,000 live births by 2030 (34). The MMR in Malawi was 634 maternal deaths per 100,000 live births in 2015 (5). This is higher than the sub-Saharan average of 546 maternal deaths per 100,000 live births in 2015 (4). The neonatal mortality rate in Malawi was 22 deaths per 1,000 live births in 2015 which was actually lower than the sub-Saharan average of 29 deaths per 1,000 live births in 2015 (8) but still much higher than the SDG 3 target (34). These statistics indicate that there is a need for further reduction in maternal and newborn mortality in Malawi and sub-Saharan Africa, more broadly. Malawi is one of the poorest countries in sub-Saharan Africa (35) and remains among the worst off on these key indicators despite the receipt of extensive amounts of overseas development funding (36). In 2016, Malawi was the fifth largest recipient of overseas development assistance to the health-related sector (36). The country received 718 million US dollars in 2016 from bilateral and multilateral donor organizations (36).

The Rural Context

While maternal and newborn mortality is generally high across Malawi and in sub-Saharan Africa (4,5,8), special attention is warranted for rural areas in particular because

mortality is often higher in rural areas than in urban areas (37). In Malawi, over 80% of men and women live in rural areas (2). Rural areas have different sociodemographic, geographic, and health service characteristics compared to their urban counterparts across the world (38). Some of these differences pertain to natural geography, local climate, tradition, culture, poverty level, resource availability, road infrastructure and transportation availability (38). When it comes to the provision of quality healthcare services, ensuring availability of transport, medicines, skilled health workforce and even health facilities is crucial for remote areas (38). However, because such resources are scarce in rural areas, policy decision-makers need to consider prioritizing the most pressing needs of the communities under tight budgetary constraints (38).

One example of this predicament is whether to strengthen existing primary healthcare facilities or invest in the construction of new primary healthcare facilities to create greater availability in remote areas (24). In either case, adequate funding support, community engagement, and health workforce competency and retention are integral elements in order for primary healthcare to gain trust in the communities even after the issue of availability is resolved (39). This is especially true since the density of physicians, nurses and midwives in Malawi was merely 3 per 10,000 population in 2010, which is critically lower than the WHO threshold of 23 physicians, nurses and midwives per 10,000 required to maintain essential levels of health services for mothers and children (40). Among the diversity of multiple competing rural health needs, this study examines the issue of health facility availability in terms of different levels and proximity to household clusters in rural Malawi.

Focus on PNC

This study focuses on the postnatal period because mothers and newborns are at a high risk of mortality during this period (10). Common causes of maternal mortality in this period are postpartum hemorrhage, sepsis and infection (10). For newborns, common causes of mortality include intrapartum related birth asphyxia, infection and prematurity among others (10). Timely and proper PNC can offer a critical opportunity to potentially reduce preventable maternal and newborn deaths (10). In terms of supporting evidence, however, no prior study has rigorously examined the association between receipt of maternal PNC and the reduction of maternal mortality (41). Studies linking newborn PNC and the reduction of newborn mortality, particularly for facility deliveries, are also difficult to find. One study by Singh, Brodish and Haney examined the associations between newborn PNC by provider type and neonatal mortality in 10 sub-Saharan African countries (15). This study found that PNC within the first week by both skilled and unskilled health providers were associated with reduction of newborn deaths between days 2 and 7 and also between days 2 and 28 (15). Despite the apparent lack of high quality evidence, the WHO nevertheless strongly recommends PNC for both the mothers and the newborns to reduce morbidity and mortality (41).

During PNC, the WHO recommends that mothers are assessed for vaginal bleeding, uterine contraction, fundal height, temperature, heart rate and blood pressure within the first 24 hours and continually monitored for danger signs afterwards (41). For newborns, it is recommended that they are assessed for clinical danger signs such as poor feeding, convulsions, breathing quickly, severe chest in-drawing, lack of spontaneous movement, very high or low body temperature and jaundice (41).

It is important that the recommended number, timing and content of maternal and newborn PNC services are provided equitably across the geographic and socioeconomic spectrums. According to a recent systematic review and meta-analysis of PNC services in low- and middle-income countries, women living in urban areas had significantly higher odds of using PNC services compared to women living in rural areas (OR: 1.36; 95% CI: 1.01 – 1.81) (42). This study concluded that within low- and middle-income settings, inequities exist in PNC use between rural and urban areas and also by education levels and socioeconomic status (42).

Study Aims

In consideration of the importance of PNC and the need for equity in rural areas, this study explores the role of health facility availability as it relates to maternal and newborn PNC use in rural Malawi. Three questions are addressed: (1) What is the availability of health facilities providing PNC in rural Malawi? (2) Where and when do mothers and newborns receive PNC in rural Malawi? and (3) What are the effects of having different types of health facilities at varying distances from household clusters on receipt of maternal and newborn PNC in rural Malawi? These are important policy questions that are expected to contribute to health services research in the context of Malawi and sub-Saharan Africa at large.

Methods

Data

Several datasets from the MDHS program were used to create a master analysis dataset. First, woman's questionnaire data from the 2015-16 MDHS was retrieved (2). The 2015-16 MDHS was implemented using a two-stage cluster sampling design. In the first stage, all 28 administrative districts in Malawi were stratified into 56 urban and rural strata (2). For each

stratum, a sample of standard enumeration areas (SEA) was selected based on the complete list of SEAs derived from the 2008 sampling frame of the Malawi Population and Housing Census (2). Selection of the SEAs also occurred in two stages (2). 173 urban SEAs and 677 rural SEAs were independently selected using probability proportional to the size of the SEA (2). Then, 30 households from urban clusters and 33 households from rural clusters were selected using an equal probability systematic selection from the complete list of households in selected SEAs (2). Selected SEAs with more than 250 households were segmented due to their large size and only one segment of households with probability proportional to the segment size was used for household listing (2). The woman's questionnaire collected various health and demographic data from all women in the reproductive age range between 15 and 49 years living in the selected households or who were found as visitors in the selected households on the day of the survey (2).

Second, the GPS coordinates of the centroids of the study clusters from the 2015-16 MDHS were linked with the woman's data through unique identifiers. The published GPS coordinates are not the exact locations of the study clusters because they have been systematically displaced using the "random direction, random distance" method (43). Each GPS coordinate was displaced a distance of up to two kilometers if it was an urban cluster. The majority of rural clusters (99%) were displaced a distance of up to five kilometers (44). A randomly selected one percent of the rural clusters were displaced a distance of up to ten kilometers (44).

The third data source was the 2013-14 MSPA. These data were collected from a census of public and private facilities in all 28 districts including facilities run by the government, CHAM, other faith-based organizations, NGOs, private for-profit organizations and others (45). The 2013-14 MSPA includes a total of four different questionnaires – Facility Inventory, Health

Provider Interview, Observation Protocols and Exit Interview questionnaires with select clients (45). The information about whether health facilities provide PNC services was obtained from the health provider interview. At each facility, the goal was to interview an average of eight health providers. For facilities that had less than eight providers, every provider was interviewed. For larger facilities, providers who were deemed most knowledgeable about their facility were selected for interview. If any health provider mentioned that he or she provides PNC services, the corresponding health facility was labeled as one providing PNC services.

Then, the GPS coordinates of the health facilities in 2013-14 MSPA were spatially linked with the woman's questionnaire data from the 2015-16 MDHS. Three distance bands around household clusters were considered for the spatial linkage. Health facilities located between 0 km and 5 km were grouped as the closest distance band. Health facilities located between 5 km and 10 km were grouped as the mid-range distance band. Health facilities located between 10 km and 15 km were grouped as the farthest distance band. Unlike the GPS coordinates of the 2015-16 MDHS household clusters, the GPS coordinates of the facilities were not displaced and reflect the true location (44). Skiles, Burgert, Curtis and Spencer compared three data scenarios where methodological considerations of geographically linking DHS household clusters with health facilities were explored (46). The study used the 2007 Rwanda SPA and the 2007-2008 Rwanda Interim DHS (46). In the study, the most ideal data scenario was having a census of all health facilities and undisplaced geographic locations of household clusters (46). Other less ideal scenarios were either having a census of all health facilities and displaced household cluster locations or having a sample of health facilities and displaced household cluster locations (46). The current study fits in with the second scenario where data were collected from a census of all health facilities in Malawi but the household cluster locations were randomly displaced. Skiles et

al. reported that in the second scenario, using a Euclidean buffer of 5 km resulted in 5.9% to 9.2% of hospitals being misclassified, 7.0% to 12.4% of health centers being misclassified and 4.9% to 7.6% of health posts being misclassified (46). The degree of misclassification error due to random displacement of household clusters in Malawi is expected to be similar to that reported in Skiles et al. but the possibility that there could be greater error in Malawian context cannot be ruled out completely.

The Woman's Questionnaire data from the 2015-16 MDHS, the GPS coordinates of the 2015-16 MDHS household clusters, the 2013-14 MSPA data and the GPS coordinates of the 2013-14 MSPA facilities are all publicly available on the DHS Program website (47) upon request.

Variables

All analyses were stratified by place of delivery. This is because types of health facilities and the proximity of these health facilities from household clusters are presumed to influence receipt of PNC differently based on where women delivered. Women who delivered at home may seek PNC at a health facility at the time of their choosing or receive a home visit by a health worker. In either circumstance, the proximity and the types of health facilities nearby women's homes can potentially influence their receipt of PNC. However, women who delivered at health facilities face a slightly different set of options. After delivery at the facility, women may receive PNC on site before returning home for the first time, return home first then seek PNC at a later time at a facility or return home first then receive a postnatal home visit by a health worker. Due to these differences in care-seeking options based on place of delivery, there were several outcome variables used for analyses (in separate models). For women who delivered at home, the

main outcomes were maternal PNC within 1 day of birth, newborn PNC within 1 day of birth, maternal PNC within 7 days of birth and newborn PNC within 7 days of birth. For women who delivered at health facilities, the main outcomes were maternal PNC between day 1 and day 7 and newborn PNC between day 1 and day 7. PNC between day 1 and day 7 was considered because women who received PNC right after delivery but before leaving the facility (to return home for the first time) will most likely do so in the first 24 hours. Looking at this time interval can potentially capture the effects for women who were discharged and came back to a facility for a first or second postnatal check. As a supplementary analysis (See Appendix Table 1), PNC within the first day was still considered for women who delivered at health facilities to check for the assumption that some women receive PNC before discharge. In this case, the types of health facilities and their proximity should not have any significant positive influence on PNC seeking decisions because women are already at the facilities. All of the outcomes are binary with "1" indicating PNC in the specified time period and "0" otherwise. There were no women who responded "don't know" for maternal PNC. For newborn PNC, less than 1% of the women responded "don't know." Among all rural women who delivered in the 5 years prior to the survey, less than 1% of the women had missing data for maternal and newborn PNC.

There were three main types of binary indicators for health facilities: clinic-level facilities providing PNC, health centers providing PNC and hospitals providing PNC. Clinic-level facilities included maternities, dispensaries, clinics and health posts. Health centers only included facilities designated as health centers. Hospitals included central hospitals, district hospitals, rural/community hospitals and other hospitals. Health centers were set apart from other lower-level facilities because they comprise the largest number among all health facilities in Malawi (45). In addition, compared to other lower-level facilities, health centers are much more likely to

offer basic client services and delivery-related services in Malawi (45). Types of facilities are meant to serve as indicators of the level of quality that can be provided at the facilities while three separate rings of buffers (0-5 km, 5-10 km and 10-15 km) indicate different levels of proximity or distance from the household clusters. See Figure 3 for a visual illustration.

Covariates in the models included season in which women gave birth, ownership of TV or a radio, whether cost of treatment is a perceived problem, women's age at the time of the survey, women's education, women's employment, household wealth, number of total births, newborn size, newborn sex, religion and region. For women who delivered at health facilities, cesarean section, whether or not women were checked before facility discharge and whether or not the newborns were checked before facility discharge were also included in the models. Number of antenatal visits was not included in the models due to potential endogeneity. Types of facilities and their proximity to household clusters could influence decisions regarding antenatal visits. Antenatal visits could also mediate the effects of facilities on PNC use, which is a classic case of endogeneity (48) where it is correlated with the error term when left in the models. Hence, the reported effects of health facilities are total effects, rather than direct effects, which account for the omitted mediated pathways (in the model) through antenatal visits.

Season in which women gave birth was coded as "warm-wet season (November to April)", "winter-dry season (May to August)" or "hot-dry season (September and October)". It was meant to proxy varying road conditions due to seasonal rainfalls. Ownership of TV or a radio was a binary variable meant to proxy potential exposure to health messages in the media. Obtaining money for treatment of any sickness being a big perceived problem was a binary variable meant to proxy financial barriers to accessing care. Women's age at the time of the survey was coded as "15 – 24", "25 – 34" and "35 – 49". Women's education was coded as

having “no education”, “primary education” and “secondary education or higher”. Employment was a binary variable with “1” indicating currently working in either formal or non-formal sectors (including but not limited to agricultural, fishery and sales) and “0” otherwise. Household wealth was a rural-specific quintile variable ranging from poorest to richest, constructed by DHS using principal components analysis (2). Number of total births was coded as “1”, “2 – 3” and “4 or more”. Newborn size was subjectively reported by the respondents as either “very large”, “larger than average”, “average”, “smaller than average” or “very small”. This variable was meant to proxy potential maternal and/or newborn complications. Newborn sex was coded as “male” or “female”. Religion was coded as “Catholic”, “Other Christian” or “Muslim, no religion or other unspecified religion”. Women with no religion or other unspecified religion were less than 1%. Region was coded as “Northern”, “Central” and “Southern” which are three administrative regions in Malawi. Cesarean section was a binary variable meant to proxy maternal complications. Whether or not mothers received a check before facility discharge and whether or not newborns received a check before facility discharge were both coded as binary variables. These two variables and cesarean section were only included for women who delivered at health facilities.

Analysis

First, a series of descriptive analyses were conducted. Sociodemographic and other background information about rural Malawian women who gave birth in the past 5 years preceding the survey are presented in Table 1. The availability of different types of health facilities within three distance bands, stratified by administrative regions is then presented in Table 2. The availability of PNC services among health facilities by distance band is presented in Table 3. The percentages of mothers and newborns receiving PNC for births in the past five

years preceding the survey are presented in Table 4. Lastly, descriptive information on the place and timing of maternal and newborn PNC, stratified by place of delivery are presented in Table 5.

Second, GEE was used in STATA version 15.1 for all of the binary outcomes, with each in separate models. Clustering of surveyed households was accounted for by specifying the error correlation structure to be "exchangeable" which means that the variance-covariance matrix for each household cluster has an identical structure (49).

In equation form, the GEE models including the aforementioned outcomes, main predictors and covariates can be summed up below. For simplicity, the meaning of each unfamiliar notation is explained in the corresponding subscript.

$$\begin{aligned} Y_{outcomes} = \alpha_{intercept} + \beta_1 Clinics_{0-5km} + \beta_2 Health\ Centers_{0-5km} + \beta_3 Hospitals_{0-5km} + \beta_4 Clinics_{5-10km} \\ + \beta_5 Health\ Centers_{5-10km} + \beta_6 Hospitals_{5-10km} + \beta_7 Clinics_{10-15km} \\ + \beta_8 Health\ Centers_{10-15km} + \beta_9 Hospitals_{10-15km} + \beta_X X_{covariates} + \varepsilon_{error\ term} \end{aligned}$$

The coefficients, denoted by β's, were converted into differential effects in STATA using the "margins" command (50). Differential effects were derived because they are more intuitive to understand than interpreting odds ratios. Differential effects can be obtained by first calculating the predicted probability of the referent category and the predicted probability of the alternative category and then taking the difference between the two. A general interpretation would be percentage point changes in the probability of the outcome given the alternative condition compared to being in the referent category. More specifically, a full interpretation for β_1, for example, would be the percentage point changes in the average probability of receiving PNC associated with having a clinic-level facility providing PNC within 5 km compared to not having

a clinic-level facility providing PNC within 5 km (averaged across all household clusters). This is controlling for the distribution of other health facilities providing PNC within 5 km, between 5 km and 10 km and between 10 km and 15 km as well as aforementioned covariates included in the models. In order to avoid repetition, however, a shortened version of the interpretation is presented in the results section. The GEE effects for home births are presented in Table 6 and the GEE effects for facility births are presented in Table 7.

Differential effects were only calculated and reported for the main predictors, as they are the focus of the analyses and covariates were carefully selected in order to obtain estimates that are as unbiased as possible for the main predictors. Lastly, all analyses, except those that are only focused on type of health facility and distance were weighted by individual women's sampling probabilities.

Results

Background Characteristics

In rural Malawi, close to two-fifths of women who gave birth in the past 5 years preceding the survey were between ages 15 and 24 (37.73%) and more than two-fifths had four or more births (41.42%). Most women had no formal education (74.84%) and were currently working in either formal or informal work (67.90%). In addition, about 66% of women belonged in the poorest, poorer or middle wealth quintile and 62% did not own a TV or a radio. Most women were either Catholic or Christian (of other denominations). About 16% of women were either Muslim, had other unspecified religion or no religion at all. In terms of perceived barriers in accessing general health care services, over half of the women considered cost of treatment (of any sickness) to be a problem (57.04%). Close to 90% of the women lived in Central and

Southern regions of Malawi. For their most recent childbirth, the majority of rural women delivered at a health facility (92.99%) and only about 5% had a cesarean section. About half gave birth during the warm and wet season (48.41%) and reported having an average-sized newborn (49.32%). Among those who delivered at a health facility, about 46% reported receiving a maternal health check before discharge and 66% reported receiving a newborn health check before discharge. The sex of the newborns were close to even (See Table 1).

Availability of Health Facility Types

In terms of health facility availability, nearly 32% of rural women had no health facilities within 5 km of where they lived, with the Central and Northern regions having significantly higher percentages with no facilities (37.22% and 32.51% respectively). Very few women lived in areas where there were no health facilities within 10 km of where they lived (2.40%). However, the Northern region had a significantly higher percentage than the rest of the regions (7.20%). Within 15 km, nearly all women had a health facility (See Table 2).

Among women living within 5 km of any clinic-level facility, the percentage of those living within 5 km of clinic-level facilities that provide PNC services was 25%. For women living within 5 km of any health center or hospital, over 90% were living within 5 km of health centers and hospitals that provide PNC services. There was a similar pattern for other distance bands as well (See Table 3).

Regarding availability of health facilities that provide PNC, very few women were living in areas where there were clinic-level health facilities providing PNC within 5 km (5.51%). In the same distance band (within 5 km), the percentage living in areas where there were health centers providing PNC was much higher at around 46%. In the Northern region, a significantly

lower percentage of women lived in areas where there were health centers providing PNC within 5 km (34.03%). About 17% of women had hospitals providing PNC within 5 km of where they lived. Notably, the percentage having hospitals providing PNC within 5 km was highest for those living in the Northern region at 27%.

In the distance band between 5 km and 10 km, about 17% of women had clinic-level facilities providing PNC. In the Northern region, this percentage was significantly lower at around 8%. With regards to health centers providing PNC in the same distance band (between 5 km and 10 km), the percentage was much higher at around 70%. However, the Northern region had the lowest percentage yet again (43.47%). About 24% of women had hospitals providing PNC in this distance band (between 5 km and 10 km).

Between 10 km and 15 km, the percentage having clinic-level facilities providing PNC was about 21% and the percentage having health centers providing PNC was about 81%. The percentage having hospitals providing PNC was about 35% (See Table 2).

Taken together, nearly 61% of women had some type of health facility (clinic, health center, or hospital) providing PNC within 5 km of where they lived and of women who had no facility providing PNC within 5 km, about 35% had some type of facility PNC availability between 5 km and 10 km. This indicates that close to 96% of women had some degree of access to facility PNC within 10 km of where they lived. The Central region had the lowest percentage of women having a facility providing PNC within 5 km (52%) and the Northern region had the lowest percentage of women having a facility providing PNC within 10 km (90%).

Place and Timing of PNC

Among rural women who delivered in the past five years preceding the survey, about 3% reported receiving maternal PNC within the first day and about 16% reported receiving maternal PNC within the first week. For newborns, nearly 3% had PNC within the first day and about 26% had PNC within the first week (See Table 4).

Most maternal and newborn PNC was provided at health facilities, 94% and 95% respectively. For those who delivered at home and received PNC, about 29% had their maternal PNC and about 16% had their newborn PNC also at home. Among the same group of women, 71% had their maternal PNC and 31% had their newborn PNC within the first 24 hours. For those who delivered at health facilities and received PNC, about 10% had maternal PNC and about 4% had newborn PNC within the first 24 hours (See Table 5).

Interpretation of the Reported GEE Effects

All reported effects in the following sections were interpreted as positive or negative associations with maternal/newborn PNC (averaged across all household clusters) controlling for the existing distribution of health facilities within 5 km, between 5 km and 10 km and between 10 km and 15 km and also controlling for other covariates aforementioned. The referent group for these effects (of the health facilities) is not having the corresponding type of health facility in the same distance band. For example, the effect of having a health center within 5 km on maternal/newborn PNC would be in comparison to not having a health center within 5 km (averaged across all household clusters), controlling for the distribution of other health facilities within 5 km, between 5 km and 10 km and between 10 km and 15 km and also controlling for other covariates. It is important to keep in mind that these are population-average estimates.

Effects of Health Facilities on PNC for Women Delivering at Home

Among women who delivered at home, having a health center providing PNC within 5 km was positively associated with maternal PNC within the first day and within 7 days. Having a hospital providing PNC farther out (between 5 km and 10 km) was positively associated with maternal PNC within 7 days.

The effects of health facilities on newborn PNC showed slightly different patterns. Having a health center or a hospital providing PNC within 5 km was positively associated with newborn PNC within the first day. There were no other significant facility effects on newborn PNC (See Table 6).

Effects of Health Facilities on PNC for Women Delivering at Health Facilities

Among women delivering in health facilities, having a health center providing PNC within 5 km was positively associated with maternal PNC between day 1 and day 7. Having a health center providing PNC farther out (between 5 km and 10 km) was also positively associated with maternal PNC between day 1 and day 7. However, having a hospital providing PNC in this distance band (between 5 km and 10 km) was negatively associated with maternal PNC between day 1 and day 7.

With regards to newborn PNC, having a clinic-level facility providing PNC within 5 km was negatively associated with newborn PNC between day 1 and day 7. Having a clinic-level facility providing PNC farther out (between 5 km and 10 km) was also negatively associated with newborn PNC between day 1 and day 7 but having a health center providing PNC in this distance band (between 5 km and 10 km) was positively associated with newborn PNC between

day 1 and day 7 (See Table 7). For the effects of the control variables, contact the researcher for full models.

Discussion

This study offered a unique opportunity to examine availability of different types of health facilities around rural household clusters in Malawi and how these facility types at varying distances influence maternal and newborn PNC. This study also highlighted that use of timely maternal and newborn PNC were very low among rural women who gave birth in the past 5 years preceding the survey. Only about 3% of all delivering mothers and 3% of newborns received PNC within the first 24 hours of birth. Receipt of PNC within the first week of birth was also low at about 16% for mothers and 26% for newborns. This suggests that increasing timely maternal and newborn PNC in general warrants more programmatic focus and attention going forward. The discussion below offers additional insight as to how we can diversify strategies based on women's place of delivery.

Implications for PNC after Home Delivery

In terms of women delivering at home, having a health center providing PNC within 5 km was positively associated with maternal PNC. Having a health center providing PNC within 5 km was also positively associated with newborn PNC within the first day. The positive effects of health centers may generally be due to their offering of a wider range of basic client services and delivery-related services compared to other lower-level facilities (45) and therefore, they might have higher recognition to women living close by. Clinic-level facilities, on the other hand, may not have the same level of recognition or familiarity to women because many of these facilities do not provide the range of maternity services that the health centers can (45).

Based on these findings, a few strategies can be considered to increase utilization of PNC after home delivery. First, training health providers based in clinic-level facilities to provide both maternal and newborn PNC could lead to more sites where PNC is available. Among women who lived within 5 km of a clinic-level facility, only about 25% had clinic-level facilities providing PNC. Second, and more importantly, emphasizing quality by ensuring that the recommended content of PNC is provided in these lower-level facilities can be an effective intervention strategy. This is because clinic-level facilities already providing PNC were not shown to be positively associated with maternal or newborn PNC. It would be important to support these lower-level facilities to provide quality PNC and to inform local communities of such changes in order to encourage use of these existing resources. Third, community health workers could also receive regular training and work closely with clinic-level facilities and health centers to provide PNC services in women's homes.

However, lack of provider training may not be the only issue. A study specifically looking at provision of PNC and uptake in four African countries reported that structures of organizational support and a system of accountability for health workers were not properly in place in Malawi (one of the four countries), leaving workers demotivated to deliver quality PNC (51). Another study looking at health workers' perspectives on worker retention and motivation in Malawi also found that major demotivating factors for health workers were generally low salary, unclear job descriptions, unequal opportunities for training, lack of an appropriate performance appraisal system and lack of supervision and feedback from the management (52). These general issues would also be a hindrance to health workers providing quality PNC as well. Hence, coupled with provider training, there may need to be a wider health sector reform at the

district management and health facility levels to establish a working accountability, supervision and feedback mechanism for providing quality PNC (51,53).

Fourth, raising community-awareness about the importance of timely PNC and the utility of clinic-level facilities for preventative PNC may also increase demand for service utilization, as there already seems to be high availability of health facilities providing PNC both within 5 km and within 10 km and also high acceptability of health facilities. In 2015 and 2016, 91% of deliveries occurred in a facility setting in Malawi (2). Hence, given the general availability and acceptability of health facilities, knowing what is offered at clinic-level facilities and health centers can be an important driver of service use. However, it would be important to couple this with quality improvement for PNC services so that women have assurance that they will receive quality preventative PNC in the lower-level facilities. One of the primary roles of clinic-level facilities is to provide preventative health services (3).

There is some evidence from a review study of demand-side interventions for maternal care that community-based mobilizations where trained facilitators led various forms of discussion groups to enhance knowledge and awareness of health problems, resulted in increased utilization of facility-based maternal care (54). This review study only considered antenatal visits, facility-based delivery and delivery with skilled birth attendants as utilization outcomes (54). Nonetheless, it showed potential that community-based mobilization interventions can increase use of facility-based maternal services (54).

Between 5 km and 10 km, having a hospital providing PNC, compared to not having one, was positively associated with maternal PNC. This indicates that across all household clusters, women delivering at home preferred the hospital for maternal PNC visits at this distance. As

mentioned previously, if clinics and health centers closer by (within 5 km) provide adequate PNC to communities, high patient load and burden of care could be shifted away from hospitals both near (within 5 km) and far (between 5 km and 10 km).

Strengthening the capacity of lower-level facilities is also beneficial for home PNC visits. This is because facilities will be able to provide more support and training to affiliated community attendants for home outreach and referrals. An evaluation of context-specific interventions designed to improve PNC in Africa found that community health workers can effectively operate as a bridge between women and the formal health sector (51). Facility-initiated interventions such as training, supervision and other incentive structures were found to strengthen the professional connection between the health facilities and the community health workers and also increase their motivations as well (51). Community health workers with stronger links to the health facilities are able to identify referral cases during home visits and encourage more women to seek facility-based care (51).

Implications for PNC after Facility Delivery

For women delivering at health facilities, a general intervention strategy should involve a streamlined referral system in which all women delivering at the facility are either visited by a health provider while in the facility or encouraged to visit the postnatal ward within the same facility site before going home for the first time after delivery. For women who cannot follow this suggestion, health providers should refer them to health facilities providing PNC near their residences and consider a home visit strategy. As with the proposed intervention strategies for women delivering at home, supporting clinic-level facilities as well as health centers to provide high quality PNC will help women delivering at health facilities to follow up on their providers'

referrals since only health centers were found positively associated with PNC visits. Along with the referrals, the literature suggests that providers should also be mindful about their attitude in giving a thorough explanation of the purpose and the benefits of care to women in general (55,56) and when providing maternal health services (57,58). In Malawi, a commonly cited reason for not wanting to receive care at the health facilities is providers' lack of explanation and poor attitude (55–58). Although asking health providers to be more "mindful" about their demeanor seems like a trivial task, it should be done considering the challenges providers in Malawi face (52,59). The Malawian health system struggles with severe understaffing (52,59) and inappropriate skill mix of health providers, especially in the delivery ward (59). As a result, health providers often report having physical, psychological and emotional stress (59). Adding another task, albeit simple, may not be effective with already over-burdened staff (52,59) if it is not complemented with appropriate organizational and sector-wide reforms boosting health worker motivations to provide quality care (51,53,60,61). As discussed before, key determinants of health worker motivation include organizational support, accountability, feedback, supervision and incentive structures (51,53,60,61).

Taken together, the proposed strategies have the potential not only to be useful for encouraging timely PNC within the first day but also making it easier for subsequent postnatal visits which are recommended three more times: on day 3, between the first and second week and at 6 weeks (14). Importantly, these strategies are also consistent with the Malawi HSSP II for 2017 to 2022 which was published in April of 2017 (3). This 5-year strategic plan issued by the Malawian Ministry of Health outlines that the Malawian government intends to "increase equitable access to and quality of health care services" in the provision of the "Essential Health Package" (3). The "Essential Health Package" encompasses a wide range of important health

services including treatment of postpartum hemorrhage (3). However, preventative PNC was not clearly delineated in the "Essential Health Package". Nevertheless, it is still considered a key component of the essential delivery-related services (10). A recommendation would be to have both maternal and newborn PNC clearly listed as essential services in the package. Other relevant objectives of the Malawi HSSP II are improving the quality of training and performance for health workers and promoting healthy behaviors through community education (3).

Availability of Health Facilities Providing PNC

Close to two-thirds of rural women had a health facility providing PNC within 5 km of where they lived with some regional variation. In the larger 10 km distance band, almost all rural women had health facilities providing PNC. In addition, facilities located beyond 10 km, regardless of type, were not significant in predicting maternal or newborn PNC. Together, these findings suggest that investing in the construction of new clinics or health centers merely to increase availability around rural communities may be a redundant effort, having little to no effect on encouraging higher utilization of PNC. Instead, resources could be directed towards raising community awareness about the importance of timely PNC, supporting quality improvement initiatives for lower-level facilities, ensuring convenient means of transportation and lowering costs of getting to the facilities and receiving care. Among rural Malawian women, only about 4% possessed either motorcycles, scooters, cars or trucks in their households for transportation (2). About 42% listed bicycles as means of transportation (2). In addition, over half of the women in this study responded that cost of treatment (of any sickness) was a perceived barrier to seeking care.

Possible Explanations for Negative Health Facility Effects

There were three statistically significant negative effects of health facilities for facility deliveries. Although the exact reasons are unknown, this could perhaps be due to several factors: (1) the selection effect of clinic-level facilities being placed in areas where health outcomes are generally poorer and utilization of health services including PNC are low. Hence, their presence is associated with lower PNC use; (2) women having little to no awareness that PNC services are offered, especially in clinic-level facilities; (3) women having low confidence that clinic-level facilities can provide quality PNC; (4) women not being able to follow through with recommended PNC after discharge for their newborns; or (5) women not being convinced that seeking additional PNC is necessary after discharge.

Limitations

There are a few limitations in the study. First, women who may have been at very high risk and died are not represented in the sample. This could potentially lead to a misrepresentation of the coverage of PNC use. Second, due to missing information, some facilities were not matched in the process of merging facility locations with the provider interviews to determine whether facilities provided PNC service. However, the number of unmatched facilities was small at around 3%. Third, the design effect of stratification was not accounted for in the analyses. Women's sampling weights and clustering were applied to individual cases however. For comparison, sensitivity analyses were conducted taking into account the full design effect (stratification, clustering and women's sampling weights) with logistic regression and the results were nearly identical to the main results presented in this study (contact the researcher for full models). The magnitude of the effects were very similar and the signs and the significance of the

effects were exactly the same. Fourth, the patterns of associations related to the facility indicators may or may not be attributed to mothers' choices given the study's model specification. In other words, these patterns of associations are not necessarily causal associations. Fifth, GPS coordinates of the household clusters have been displaced at a random angle and a random distance from their original locations. Although using buffers with reasonable distances to link facilities and household clusters is expected to somewhat account for the displacement (44), it introduces "noise" in the analysis nonetheless. However, even in the presence of such "noise", knowing the exact locations and characteristics of all operational health facilities (based on 2013 data) in Malawi allowed the unique opportunity to investigate the study's research questions.

Conclusion

The main findings of the study offer important insights for future policy considerations in the context of rural Malawi and comparable regions in sub-Saharan Africa at large. Clinic-level facilities and health centers that currently do not provide PNC should be supported to provide quality PNC to women and newborns. Quality improvement strategies can be considered for lower-level facilities that already provide PNC. Women who deliver at health facilities should receive their first PNC visit (for both the mother and the newborn) before they leave the facility as a standard of practice. Health providers should also mindfully explain the importance of timely PNC and refer women to facilities providing PNC near their residences for further visits. Home visits can also be promoted to reach both women who delivered in facilities as well as the smaller number of women who did not. Lastly, allocating resources to the construction of new facilities does not seem to be a good strategy for increasing utilization of PNC. Instead, more effective strategies are: (1) training providers to be able to perform quality PNC at all facilities; (2) establishing a working system of support, accountability, feedback, supervision and

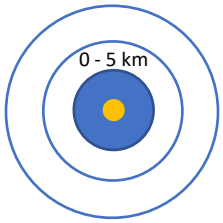
incentives at the organizational and district levels to mitigate issues of staff frustrations and lack of motivation; and (3) increasing community awareness about the importance of seeking timely PNC and about the utility of lower-level facilities for receiving preventative PNC.

Ethics Approval

This study was reviewed and exempted from ethics approval by the Institutional Review Board at the University of North Carolina at Chapel Hill.

Figure 3. Main Predictors of the Analysis

Presence of health facility located within 5 km of household cluster (providing PNC)



Clinic-level facilities

Health Centers

Hospitals

Presence of health facility located between 5 km and 10 km from household cluster (provided PNC)

Clinic-level facilities

Health Centers

Hospitals

Presence of health facility located between 10 km and 15 km from household cluster

Clinic-level facilities

Health Centers

Hospitals

Note.

The yellow dot in the middle represents a household cluster

Each ring represents a distance buffer (a total of three buffers)

The blue shaded area represents where the health facilities are located

There are a total of 9 main predictor variables

Table 1. Background characteristics of rural women who gave birth in the past 5 years preceding the survey in Malawi, MDHS 2015-16

	Total	
	n	%
Age		
15-24	4368	37.73%
25-34	4879	42.15%
35-49	2329	20.12%
Education		
None	8663	74.84%
Primary	2453	21.19%
Secondary or higher	460	3.97%
Employment		
Yes	7861	67.90%
No	3715	32.10%
Rural Wealth Quintile		
Poorest	2770	23.92%
Poorer	2510	21.68%
Middle	2307	19.93%
Richer	2134	18.44%
Richest	1855	16.03%
Religion		
Catholic	1877	16.22%
Other Christian	7884	68.11%
Muslim/other/ no religion	1814	15.67%
Number of births		
1	2655	22.94%
2-3	4126	35.64%
4+	4795	41.42%
TV/Radio Ownership		
Yes	4370	38.06%
No	7111	61.94%
Cost of treatment (of any sickness) being a perceived problem		
Yes	6602	57.04%
No	4974	42.96%
Region of residence		
Northern	1360	11.75%

Central	4865	42.03%
Southern	5351	46.22%
Place of delivery		
Home	798	7.01%
Health Facility	10599	92.99%
C-section		
Yes	624	5.41%
No	10911	94.59%
Maternal health check before discharge from the health facility		
Yes	4847	45.91%
No	5711	54.09%
Newborn health check before discharge from the health facility		
Yes	6940	65.73%
No	3618	34.27%
Newborn size		
Very large	1112	9.69%
Larger than average	2831	24.67%
Average	5659	49.32%
Smaller than average	1354	11.80%
Very small	519	4.52%
Newborn sex		
Male	5805	50.15%
Female	5771	49.85%
Season in which women gave birth		
Warm-wet	5604	48.41%
Winer-dry	3733	32.25%
Hot-dry	2239	19.34%

Note.

Columns within a categorical variable sum to 100%

Observations are weighted counts

Table 2. Availability of health facilities providing PNC within three distance bands of rural household clusters in Malawi, MSPA 2013-14 & MDHS 2015-16

	Total		Regions					
			Northern		Central		Southern	
	n	%	n	%	n	%	n	%
Women who have no health facilities:								
within 5 km***	6088	31.52%	1205	32.51%	2450	37.22%	2433	26.95%
within 10 km***	463	2.40%	267	7.20%	113	1.72%	83	0.92%
within 15 km***	83	0.43%	54	1.46%	0	0.00%	29	0.32%
Women who have health facilities providing PNC:								
within 5 km***	11719	60.67%	2289	61.76%	3395	51.58%	6035	66.85%
between 5 km and 10 km (but none within 5 km)***	6743	34.91%	1061	28.63%	2882	43.79%	2800	31.02%
within 10 km***	18462	95.58%	3350	90.39%	6277	95.37%	8835	97.87%
Type of facility providing PNC within 5 km								
Clinic-level facilities***	1064	5.51%	179	4.83%	275	4.18%	610	6.76%
Health centers***	8955	46.36%	1261	34.03%	2675	40.64%	5019	55.60%
Hospitals***	3334	17.26%	1005	27.12%	809	12.29%	1520	16.84%
Type of facility providing PNC between 5 km and 10 km								
Clinic-level facilities***	3364	17.42%	298	8.04%	786	11.94%	2280	25.26%
Health centers***	13510	69.95%	1611	43.47%	4491	68.23%	7408	82.06%
Hospitals***	4662	24.14%	668	18.02%	1454	22.09%	2540	28.14%
Type of facility providing PNC between 10 km and 15 km								
Clinic-level facilities***	4016	20.79%	543	14.65%	859	13.05%	2614	28.96%
Health centers***	15707	81.32%	2344	63.25%	5591	84.94%	7772	86.10%
Hospitals***	6758	34.99%	992	26.77%	2098	31.87%	3668	40.63%

Note.

***p<0.001; bivariate chi-square tests were performed (each level of facility vs. regions)

Total number of observations is 19,315

Column percentages were reported corresponding to the category

Observations belonging in different categories of facilities within each buffer are not mutually exclusive (i.e. one observation could be counted multiple times if it has a clinic-level facility, a health center and a hospital all within 5 km of where it is)

Table 3. Availability of PNC services among health facilities, MDHS 2015-16

	Total	Facilities providing PNC	
	N	N	%
Within 5 km of household cluster			
Clinic-level	4226	1064	25.18%
Health center	9536	8955	93.91%
Hospital	3357	3334	99.31%
Between 5 km and 10 km of household cluster			
Clinic-level	8200	3364	41.02%
Health center	14193	13510	95.19%
Hospital	4817	4662	96.78%
Between 10 km and 15 km of household cluster			
Clinic-level	10363	4016	38.75%
Health center	16253	15707	96.64%
Hospital	6813	6758	99.19%

Note.

Total number of observations is 19,315

Table 4. Percentages of rural women who gave birth in the past 5 years preceding the survey with maternal/newborn PNC, MDHS 2015-16

	Total	
	n	%
Maternal PNC within 24 hours	367	3.17%
Maternal PNC within the first week	1877	16.21%
Newborn PNC within 24 hours	340	2.94%
Newborn PNC within the first week	2992	25.85%

Note.

There were 11,576 rural women who gave birth in the past 5 years preceding the survey (weighted)

Table 5. Place and timing of maternal/newborn PNC among rural women receiving PNC in Malawi, MDHS 2015-16

			Place of Delivery			
	Total		Home		Health Facility	
	n	%	n	%	n	%
Place of Maternal PNC						***
Home	151	6.35%	46	29.46%	105	4.74%
Health Facility	2229	93.65%	110	70.54%	2119	95.26%
Timing of Maternal PNC						***
Within 24 hrs	329	13.98%	106	70.56%	223	10.12%
24 hrs to Day 3	142	6.02%	13	8.41%	129	5.86%
Day 3 to Week 1	1361	57.90%	14	9.40%	1347	61.20%
After Week 1	520	22.10%	17	11.63%	502	22.81%
Place of Newborn PNC						***
Home	221	4.67%	54	15.60%	167	3.80%
Health Facility	4505	95.33%	294	84.40%	4211	96.20%
Timing of Newborn PNC						***
Within 24 hrs	301	6.39%	108	31.12%	192	4.42%
24 hrs to Day 3	162	3.45%	26	7.58%	136	3.12%
Day 3 to Week 1	2462	52.34%	67	19.37%	2395	54.97%
After Week 1	1779	37.82%	146	41.92%	1634	37.50%

Note.

***p<0.001; bivariate chi-square tests were performed against place of delivery

Columns within a categorical variable sum to 100%

Observations are weighted counts

Table 6. The effects of different types and proximities of health facilities on maternal/newborn PNC among rural women who gave birth at home in Malawi, MDHS 2015-16

	Maternal				Newborn			
	PNC within 1 day		PNC within 7 days		PNC within 1 day		PNC within 7 days	
	DE	[95% CI]	DE	[95% CI]	DE	[95% CI]	DE	[95% CI]
Type and Proximity of Health Facilities								
Within 5 km of household cluster								
Clinic-level								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	0.046	[-0.091, 0.184]	0.124	[-0.012, 0.259]	-0.035	[-0.179, 0.108]	0.042	[-0.137, 0.221]
Health center								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	0.079**	[0.020, 0.138]	0.073*	[0.012, 0.135]	0.068*	[0.003, 0.132]	0.063	[-0.020, 0.146]
Hospital								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	0.028	[-0.053, 0.108]	-0.002	[-0.087, 0.082]	0.137*	[0.012, 0.263]	0.117	[-0.053, 0.287]
Between 5 km and 10 km of household cluster								
Clinic-level								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	-0.032	[-0.110, 0.046]	-0.003	[-0.076, 0.069]	0.030	[-0.034, 0.094]	0.037	[-0.045, 0.118]
Health center								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	0.039	[-0.028, 0.105]	0.028	[-0.037, 0.092]	0.028	[-0.043, 0.099]	0.041	[-0.039, 0.121]
Hospital								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	0.062	[-0.0004, 0.125]	0.073*	[0.012, 0.134]	0.030	[-0.029, 0.089]	0.066	[-0.015, 0.148]
Between 10 km and 15 km of household cluster								
Clinic-level								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	-0.062	[-0.134, 0.010]	-0.074	[-0.150, 0.003]	-0.009	[-0.077, 0.060]	0.006	[-0.082, 0.093]
Health center								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	-0.012	[-0.093, 0.070]	-0.035	[-0.119, 0.049]	0.050	[-0.038, 0.138]	-0.020	[-0.123, 0.082]

Hospital								
No facility (ref)	-	-	-	-	-	-	-	-
Facility	0.027	[-0.034, 0.087]	0.025	[-0.042, 0.092]	-0.000	[-0.059, 0.059]	0.009	[-0.072, 0.089]

Note.

*p<0.05 **p<0.01

Total number of women who delivered at home is 691;
Number of observations for maternal outcomes is 665; Number of observations for newborn outcomes is 664

The outcomes were Maternal PNC within 1 day, Maternal PNC within 7 days, Newborn PNC within 1 day or Newborn PNC within 7 days in four separate GEE models

The main predictors (separate binary indicators) in the GEE models were whether or not there was: a clinic-level facility providing PNC within 5 km; a health center providing PNC within 5 km; a hospital providing PNC within 5 km; a clinic-level facility providing PNC between 5 km and 10 km; a health center providing PNC between 5 km and 10 km; a hospital providing PNC between 5 km and 10 km; a clinic-level facility providing PNC between 10 km and 15 km; a health center providing PNC between 10 km and 15 km; a hospital providing PNC between 10 km and 15 km

Covariates included in the GEE models were season in which women gave birth, ownership of TV or radio, whether cost of treatment is a perceived problem, women's age, women's education, women's employment, household wealth, number of births, newborn size, newborn sex, religion and region

Table 7. The effects of different types and proximities of health facilities on maternal/newborn PNC among rural women who gave birth at health facilities in Malawi, MDHS 2015-16

	Maternal		Newborn	
	PNC between Day 1 and Day 7		PNC between Day 1 and Day 7	
	DE	[95% CI]	DE	[95% CI]
Type and Proximity of Health Facilities				
Within 5 km of household cluster				
Clinic-level				
No facility (ref)	-	-	-	-
Facility	-0.023	[-0.077, 0.032]	-0.134**	[-0.210, -0.057]
Health center				
No facility (ref)	-	-	-	-
Facility	0.032*	[0.004, 0.059]	0.009	[-0.023, 0.041]
Hospital				
No facility (ref)	-	-	-	-
Facility	0.034	[-0.005, 0.074]	0.020	[-0.024, 0.065]
Between 5 km and 10 km of household cluster				
Clinic-level				
No facility (ref)	-	-	-	-
Facility	0.002	[-0.031, 0.034]	-0.047*	[-0.090, -0.004]
Health center				
No facility (ref)	-	-	-	-
Facility	0.044**	[0.014, 0.074]	0.069***	[0.034, 0.105]
Hospital				
No facility (ref)	-	-	-	-
Facility	-0.042**	[-0.072, -0.011]	-0.010	[-0.043, 0.023]
Between 10 km and 15 km of household cluster				
Clinic-level				
No facility (ref)	-	-	-	-
Facility	-0.004	[-0.036, 0.028]	0.030	[-0.010, 0.070]
Health center				
No facility (ref)	-	-	-	-

	Facility	0.007	[-0.027, 0.041]	0.030	[-0.012, 0.072]
Hospital					
	No facility (ref)	-	-	-	-
	Facility	-0.002	[-0.031, 0.027]	-0.013	[-0.045, 0.019]

Note.

*p<0.05 **p<0.01 ***p<0.001

Total number of women who delivered at the health facility is 10,266;
Number of observations for maternal outcomes is 10,083; Number of observations for newborn outcomes is 10,029

The outcomes were Maternal PNC between day 1 and day 7 or Newborn PNC between day 1 and day 7 in two separate GEE models

The main predictors (separate binary indicators) in the GEE models were whether or not there was: a clinic-level facility providing PNC within 5 km; a health center providing PNC within 5 km; a hospital providing PNC within 5 km; a clinic-level facility providing PNC between 5 km and 10 km; a health center providing PNC between 5 km and 10 km; a hospital providing PNC between 5 km and 10 km; a clinic-level facility providing PNC between 10 km and 15 km; a health center providing PNC between 10 km and 15 km; a hospital providing PNC between 10 km and 15 km

Covariates included in the GEE models were season in which women gave birth, ownership of TV or radio, whether cost of treatment is a perceived problem, women's age, women's education, women's employment, household wealth, number of births, newborn size, newborn sex, religion, region, cesarean section and whether or not the mother or the newborn (depending on the outcome) was checked before discharge from facility

CHAPTER 3. INFLUENCES OF HEALTH FACILITY TYPE FOR DELIVERY AND EXPERIENCE OF CESAREAN SECTION ON MATERNAL AND NEWBORN PNC BEFORE FACILITY DISCHARGE IN MALAWI

Introduction

Over the years, there have been significant policy discussions and updates to guidelines on encouraging skilled attendance at delivery in contexts where maternal and newborn mortality is high (62). The WHO for one has had a few changes to its policy position regarding the matter, going from supporting the training of traditional birth attendants in the 1960s, and linking them to the larger health care system to encouraging delivery by medically-trained professionals for all births today (62,63). This is because skilled assistance by medically trained doctors, nurses and midwives at birth could potentially prevent and manage many of the complications that would lead to mortality (64). A meta-analysis of population-based cohort studies on the association between place of delivery and maternal and perinatal mortality in sub-Saharan Africa found that perinatal mortality was 21% higher for women delivering at home compared to those delivering at health facilities (65). On the contrary, the opposite relationship was true for maternal mortality whereby women delivering in health facilities had poorer outcomes (65). This may be confounded by women with higher risk of delivery complications and mortality seeking facility-based care (65). Overall, rigorous scientific evidence linking skilled attendance at delivery to the reduction of maternal and perinatal mortality in developing contexts is still insufficient. Regardless, this strategy has been promoted and has seen noticeable shifts in its favor in recent

years (64). The rate of facility delivery has sizably increased in developing regions globally (64), including sub-Saharan Africa even though its increase was less dramatic compared to other regions of the world (64,66).

In Malawi, one of the poorest countries in sub-Saharan Africa, facility delivery has also risen quite significantly over the years (from 1992 to 2015-16), going from 55% to 91%, respectively (2). Considering that facility delivery has now become much more popular in Malawi than home deliveries, 91% versus 7% respectively (2), it is important to make sure that women take full advantage of all the benefits that come with delivering at a health facility even after birth. One of the major advantages of delivering at a health facility for mothers and their newborns is the opportunity to receive timely postnatal checks before discharge (14). The WHO in fact recommends that all women and their newborns receive continuous care for at least the first 24 hours after birth in the delivering health facility before discharge (14).

This gives mothers and newborns an opportunity to be professionally checked and monitored for any potential and unexpected danger signs that might arise during this period (41). During the first 24 hours after birth, medically trained providers at the health facility are advised to give all newborns an immediate assessment of danger signs, a clinical examination at one hour of birth and another examination right before discharge (41). For all delivering mothers, health providers are advised to check for excessive bleeding, signs of infection, uterine contraction, fundal height and any difficulty with breastfeeding (41).

A number of studies in the past have looked at determinants of PNC (16,18–22,31). However, most of these studies have used PNC within a certain time period as the outcome without making a distinction between PNC before discharge and PNC after discharge for women

delivering at health facilities (16,18–22,31). This is an important distinction to make because conceptually and practically, factors associated with PNC before discharge have less to do with women's personal preferences and choices. Rather, it has more to do with the care environment.

This conceptualization also aligns with the Three Delays Model (32) because receipt of PNC before facility discharge depends on factors pertaining to the health system which is outside of the women's control. In the Three Delays Model, the first and second phases of delay pertain to barriers in deciding to seek facility-based care and in reaching facility-based care once the decision has been made (32). The third phase of delay consists of system-level barriers where even after women reach the health facilities, they are unable to receive adequate care due to poor staffing at the facility, lack of provider skills and knowledge and low stock of essential supplies and medicines (32). As facility delivery continues to rise and the barriers to facility PNC potentially exist in the "third phase" for this context, a proper assessment of the current situation is warranted.

This study therefore aims to address this seeming research gap by examining whether delivery in different types of health facilities is associated with maternal and newborn PNC before facility discharge in Malawi. Because cesarean section is an indicator for high risk deliveries, receipt of cesarean section will be examined as a potential mediator between type of health facility where women delivered and maternal and newborn postnatal health check before discharge. The direct influences of other maternal and newborn characteristics such as age, education, number of births, newborn size, residence and region will also be examined in this context.

Methods

Data

Women's questionnaire data from the 2015-16 MDHS were used for the study. The 2015-16 MDHS collected a wide range of information including demographic indicators, fertility and mortality measures, family planning knowledge and use, immunization coverage, maternity care, infant and young child feeding, nutritional status, HIV and more (2). The survey was conducted with a two-stage stratified cluster sampling design (2). Each of the 28 administrative districts in Malawi was stratified into urban and rural strata (2). From each strata, a sample of standard enumeration areas, which consist of about 235 households on average, were selected for household listing serving as a sampling frame (2). In the second stage, 30 households were selected from each urban household listing or cluster and 33 households were selected from each rural household listing or cluster (2). In the selected households, women's questionnaires were administered to women between the ages of 15 and 49 who were either residents there or were visitors from the night before the survey (2).

Variables

Three categorical endogenous variables were examined in the study: whether or not mothers received a postnatal check before discharge from the facility, whether or not newborns received a postnatal check before discharge from the facility and whether or not women received cesarean section during delivery. For all three endogenous variables, "1" indicated receipt of services and "0" indicated otherwise. There were no women who responded "don't know" for maternal PNC before discharge. For newborn PNC before discharge, about 1% of the women

responded “don’t know.” Among all women who delivered in the 5 years prior to the survey, about 7% of them had missing data for maternal and newborn PNC before discharge.

Winship and Mare mention in their important work on structural equations for discrete data (67) that binary indicators can represent one of two ideas: an indicator that measures a discrete event or an indicator that serves as a proxy for an unobserved underlying continuous variable (67). In this study, delivery by cesarean section is treated as a proxy variable for some underlying continuous phenomenon. The final decision to perform cesarean section is likely based on whether pregnant women, who are all on an unobserved continuum of complication risk, display characteristics that exceed providers’ threshold levels for risk of complication. Hence, this study acknowledges that the underlying continuous variable exists for cesarean section, albeit unobserved.

The main predictor of interest in the study was type of health facility where women delivered. It was coded to have four categories: (1) government hospital; (2) government health center, government health post and other public sector facilities (not specified in the dataset); (3) private hospital and CHAM hospitals; and (4) CHAM health centers, BLM (private NGO) and other private sector facilities (not specified in the dataset). Health centers, health posts and other unspecified facilities were grouped together because only a small number delivered in health posts and other unspecified facilities (around 1.44%) and deliveries are typically done in health centers or hospitals in Malawi (45). All of these facility categories represent the major health service providers in Malawi (45). However, there are a couple of differences between health facilities based on their type and affiliation (public and private). Government-owned facilities provide services free of charge while privately-owned facilities charge a fee (45). Health facilities of various types and affiliations also have very different resources for service readiness

including basic amenities, equipment, infection control, diagnostic capacity, essential medicines, quality assurance, client feedback and provider training (45). The main predictor variable was meant to capture these differences in general service readiness as well as potential differences in PNC practices by types and affiliations of health facilities.

Other exogenous variables included in the model were women's age, women's education, household wealth, number of all births, newborn size, region of the country and residence. Women's age was coded to be either "15 – 24", "25 – 34" or "35 – 49". Women's education was coded to be either "no education", "primary education" or "secondary education". Household wealth was a quintile variable constructed by DHS using principal components analysis (2) and it was coded as either "poorest", "poorer", "middle", "richer" or "richest". Number of all births was coded as either "1", "2 – 3" or "4 or more". Newborn size was coded as either "very large", "larger than average", "average", "smaller than average" or "very small". Region of the country was coded as either "northern", "central" or "southern". Residence was coded as either "urban" or "rural".

In this study, receiving a postnatal check before facility discharge was hypothesized to be more of a function of the type of facility where women delivered and other "noticeable" maternal and newborn characteristics that could further attract attention by the providers in the respective facilities. However, sociodemographic variables such as women's education and household wealth were also included in the model to test for their effects.

Descriptive analyses of the study variables are presented in Tables 8, 9 and 10. Table 8 presents the coverage of maternal and newborn postnatal health checks before facility discharge among women who gave birth in the 5 years prior to the survey. Table 9 presents descriptive

summary of the analysis variables for women who gave birth in the 5 years prior to the survey. Table 10 presents the percentages of women and newborns receiving postnatal health checks before discharge by type of delivering health facility.

Path Diagram and Simultaneous Equations

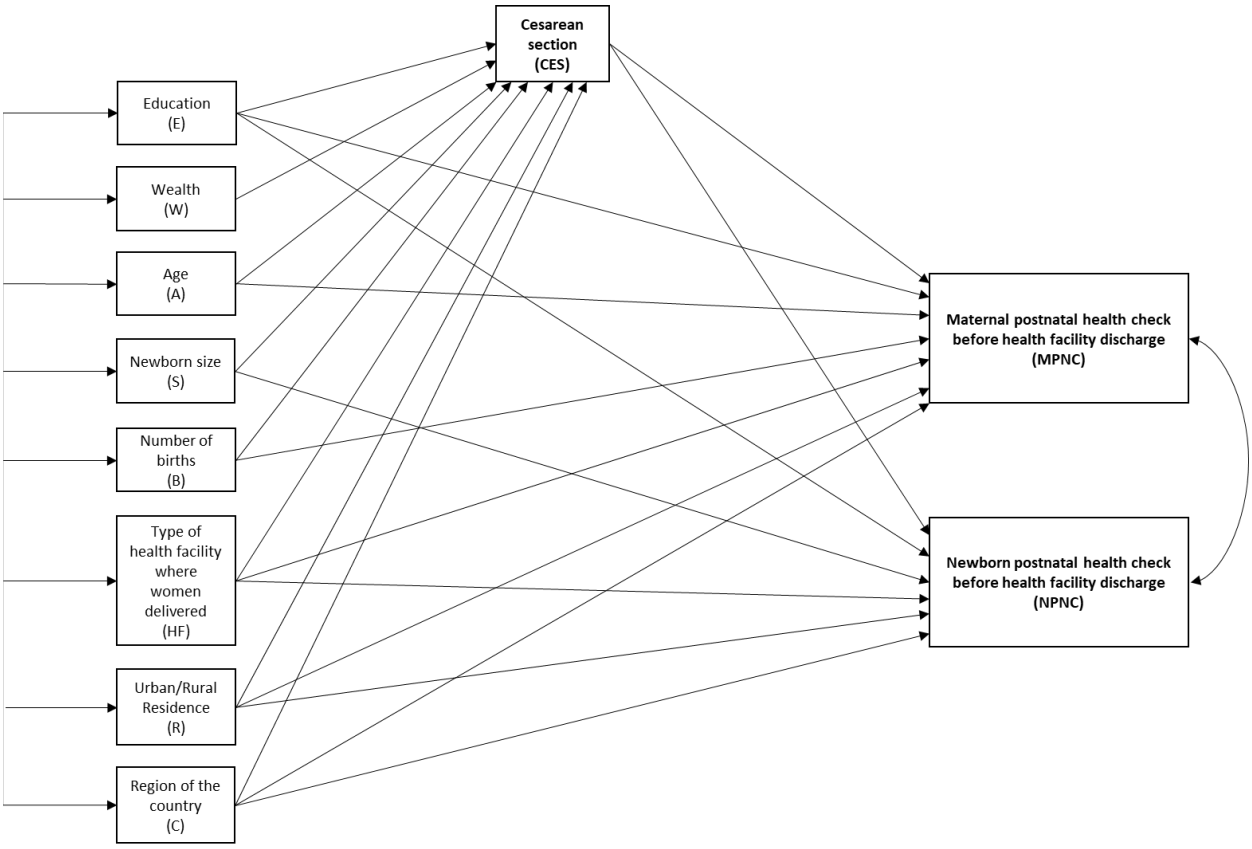


Figure 4. Path diagram of the hypothesized model

$$MPNC = \alpha_{MPNC} + \beta_1 CES + \beta_2 E_2 + \beta_3 E_3 + \beta_4 A_2 + \beta_5 A_3 + \beta_6 B_2 + \beta_7 B_3 + \beta_8 HF_2 + \beta_9 HF_3 + \beta_{10} HF_4 + \beta_{11} R + \beta_{12} C_1 + \beta_{13} C_3$$

$$NPNC = \alpha_{NPNC} + \beta_{14} CES + \beta_{15} E_2 + \beta_{16} E_3 + \beta_{17} S_1 + \beta_{18} S_2 + \beta_{19} S_4 + \beta_{20} S_5 + \beta_{21} HF_2 + \beta_{22} HF_3 + \beta_{23} HF_4 + \beta_{24} R + \beta_{25} C_1 + \beta_{26} C_3$$

$$CES = \alpha_{CES} + \beta_{27} E_2 + \beta_{28} E_3 + \beta_{29} W_1 + \beta_{30} W_2 + \beta_{31} W_4 + \beta_{32} W_5 + \beta_{33} A_2 + \beta_{34} A_3 + \beta_{35} S_1 + \beta_{36} S_2 + \beta_{37} S_4 + \beta_{38} S_5 + \beta_{39} B_2 + \beta_{40} B_3 + \beta_{41} HF_2 + \beta_{42} HF_3 + \beta_{43} HF_4 + \beta_{44} R + \beta_{45} C_1 + \beta_{46} C_3$$

$COV(MPNC, NPNC) \neq 0$,

$COV(E,W) \neq 0$, $COV(E,A) \neq 0$, $COV(E,S) \neq 0$, $COV(E,B) \neq 0$, $COV(E,HF) \neq 0$, $COV(E,R) \neq 0$, $COV(E,C) \neq 0$,

$COV(W,A) \neq 0$, $COV(W,S) \neq 0$, $COV(W,B) \neq 0$, $COV(W,HF) \neq 0$, $COV(W,R) \neq 0$, $COV(W,C) \neq 0$,

$COV(A,S) \neq 0$, $COV(A,B) \neq 0$, $COV(A,HF) \neq 0$, $COV(A,R) \neq 0$, $COV(A,C) \neq 0$,

$COV(S,B) \neq 0$, $COV(S,HF) \neq 0$, $COV(S,R) \neq 0$, $COV(S,C) \neq 0$,

$COV(B,HF) \neq 0$, $COV(B,R) \neq 0$, $COV(B,C) \neq 0$,

$COV(HF,R) \neq 0$, $COV(HF,C) \neq 0$,

$COV(R,C) \neq 0$

Analysis

The model hypothesizes that: (1) cesarean section, age of the mother, education of the mother, number of births, type of health facility where women delivered, urban/rural residence and region of the country influence maternal postnatal health check before discharge; (2) cesarean section, newborn size, education of the mother, type of health facility where women delivered, urban/rural residence and region of the country influence newborn postnatal health check before discharge; and finally, (3) all of the exogenous variables in the model influence delivery by cesarean section. Other variations of the model where household wealth predicted both maternal and newborn postnatal checks before discharge and newborn size predicted maternal postnatal check before discharge were also tested. However, the current model specification yielded the best model fit (more on model fit indices later).

Because cesarean section is in the mediated pathway for all of the exogenous variables in the model, indirect effects of these variables on maternal and newborn postnatal health checks can be calculated. In the case where exogenous variables predict the latent continuous variable

underlying the binary mediator and the same latent continuous variable is used to predict maternal and newborn PNC, the calculation of indirect effects just involves the product of two coefficients: the coefficient of an exogenous variable in predicting cesarean section and the coefficient of cesarean section in predicting maternal or newborn PNC (67). This corresponds to the model 1 specification in the article by Winship and Mare (67). The total effects are the sum of the direct effects and the indirect effects (67).

The indirect effects through cesarean section and the total effects were only calculated and interpreted for type of health facility where women delivered. For the rest of the exogenous variables, only the direct effects were reported and interpreted. This is because the primary interest of the study is to distinguish the direct effects of the delivering health facilities from their indirect effects through cesarean section. According to the MSPA 2013-14 report, cesarean section is only done in hospitals (45). However, the indirect effects and the total effects were also calculated for government and CHAM health centers because some women in the sample responded that they have received cesarean section in these lower-level facilities as well. The direct effects of other exogenous variables will indicate whether observable maternal and newborn characteristics as well as the socioeconomic background influence postnatal health check at the facilities outside of the mediated pathway through cesarean section.

The hypothesized model also shows that all of the exogenous variables are correlated in some way. It does not specify what the directions of the associations are among the exogenous variables. This is because those relationships are not of interest in the study. However, acknowledging that these variables are correlated is important for model specification and fit. Lastly, the residuals of maternal postnatal health check before discharge and newborn postnatal health check before discharge are hypothesized to correlate in the model. Due to this correlation,

the model is not “fully recursive”. However, it is still “recursive” because there are no feedback relationships present in the model.

Checks for Model Identification and Specification

There are many rules of identification reported in the literature to help researchers make sure that their models are identified. One of the rules of identification that applies to recursive models with correlated errors is that no variable influences another variable with the error terms of each being correlated (68). According to Brito and Pearl, this is a sufficient condition of identification for recursive models with correlated errors (68). The illustrated path diagram in Figure 4 shows that this rule applies and is sufficient for identification.

Several model fit indices with the full information estimation method showed that the model specification fit the data well. Specifically, six different model fit indices were considered to assess if the model specification was appropriately fitting the data. These indices were the overall chi-square test, Tucker-Lewis index, incremental fit index, relative noncentrality index, root mean square error of approximation and the Bayesian information criterion (69,70). These fit indices can be calculated as follows (69,70):

$T_b = chi\ square\ test\ statistic\ of\ the\ baseline\ model$
$df_b = degrees\ of\ freedom\ of\ the\ baseline\ model$
$T_m = chi\ square\ test\ statistic\ of\ the\ hypothesized\ model$
$df_m = degrees\ of\ freedom\ of\ the\ hypothesized\ model$
$N = number\ of\ observations\ used\ in\ the\ analysis$
$F_{ML} = maximum\ likelihood\ fit\ function\ value$
$Chi\ square\ test\ statistic = (N-1)F_{ML}$

$$TLI = \frac{\frac{T_b}{df_b} - \frac{T_m}{df_m}}{\frac{T_b}{df_b} - 1}$$

$$IFI = \frac{T_b - T_m}{T_b - df_m}$$

$$RNI = \frac{(T_b - df_b) - (T_m - df_m)}{T_b - df_b}$$

$$RMSEA = \sqrt{\frac{T_m - df_m}{df_m(N-1)}}$$

$$BIC = T_m - df_m \ln(N)$$

The overall chi-square test has the null hypothesis that the model implied means and covariance matrix are equal to the means and the covariance matrix in the data (69,70). Rejecting the null hypothesis would indicate that the model implied means and the covariance matrix are not consistent with those in the data and hence, require re-specification of the model. The chi-square test of the hypothesized model was statistically insignificant which meant that there was no evidence to reject the null hypothesis.

The Tucker-Lewis index, the incremental fit index and the relative noncentrality index all utilize information from the chi-square test statistics of the baseline model and the hypothesized model (69). In comparison to the acceptable standard of 0.95 as the cutoff for an appropriate model fit (69), the current model specification seemed to be a good fit to the data by all three measures.

The root mean square error of approximation also uses the chi-square test statistic of the hypothesized model and its degrees of freedom (69). A value less than 0.06 indicates a good fit (69). The root mean square error for the hypothesized model was very close to 0 indicating a good fit. Finally, the Bayesian information criterion for the hypothesized model had a large negative value which indicated that it was preferred over the compared saturated model (70).

In summary, all of the six model fit indices suggested that the current model specification is consistent with the data and that no other modifications need to be made based solely on model fit. The summary of the model fit indices can be found in Table 11.

Table 12 presents probit regression coefficients from the simultaneous equations model that were estimated using Mplus version 8.1. The probit regression coefficients were adjusted for cluster sampling and for women's individual sampling weights. The signs of the probit regression coefficients can be interpreted as positive or negative influences on the binary outcomes themselves and on their underlying continuous variables. Model-implied predicted probabilities from the probit regression coefficients were also calculated for a few meaningful scenarios and were reported in Table 13.

Lastly, because all endogenous variables in the model are categorical, diagonally-weighted least squares were used instead of maximum likelihood estimation. Using diagonally-weighted least squares is ideal with endogenous categorical variables for several reasons. It corrects for the model-implied means and the covariance matrix of the true underlying continuous distribution of a categorized variable being different than the categorized variable itself. The diagonally-weighted least squares approach also does not require a distributional assumption as does the maximum likelihood approach. This is important because distributional assumptions for categorized variables typically fail even if they are true for the corresponding underlying continuous variable. The "WLSMV" estimator under the type "Complex" was used in Mplus version 8.1 in order to implement diagonally-weighted least squares.

Results

Among women who gave birth in the past 5 years preceding the survey, 47% had maternal postnatal health check and 68% had newborn postnatal health check before being discharged from the health facility (See Table 8). The majority of women either delivered in government hospitals (31%) or government health centers and health posts (56%). Although not shown in the tables, very few women actually delivered in government health posts and other public facilities (around 2%). Delivery in private health facilities was also rare with 9% delivering in private hospitals and 5% delivering in private health centers, BLM and others. During delivery, only about 7% received cesarean section and about half of the newborns were either in the large or small categories (combined 51%). A combined 15% of the newborns were either in the very large or very small categories.

Most women who gave birth in the past 5 years preceding the survey fell into the age group 15 to 34 (82%), had two or more births (74%), lived in rural areas (85%) and in central and southern regions of Malawi (88%). As for education, 68% of women had no education and 24% had primary education. 44% of women belonged in either the “poorest” or “poorer” wealth quintiles and 36% of women belonged in the “richer” or “richest” wealth quintiles (See Table 9).

Among women delivering in government hospitals, 53% received a maternal postnatal health check and 72% received a newborn postnatal health check. Among women delivering in government health centers, government health posts or other public facilities, 42% received a maternal postnatal health check and 64% received a newborn postnatal health check. For women delivering in private, CHAM or mission hospitals, 60% received a maternal postnatal health check and 77% received a newborn postnatal health check. Lastly, among deliveries in CHAM

health centers, BLM and others, 48% received a maternal postnatal health check and 71% received a newborn postnatal health check (See Table 10).

For the main predictor of interest, type of health facility where women delivered, the direct effects, the indirect effects via cesarean section and the total combined effects were examined separately. Delivering in a government hospital was the referent category to which deliveries in all other health facilities were compared. In comparison to the direct effect of delivering in a government hospital, the direct effect of delivering in a government health center, health post or others was not significant on maternal or newborn postnatal health check before discharge. The direct effects of delivering in private, CHAM or mission hospitals were significantly higher on both maternal and newborn postnatal health checks before discharge compared to the direct effect of delivering in a government hospital. As for the indirect effects via cesarean section, the effects of delivering in government health centers, government health posts, CHAM health centers, BLM or others were significantly lower on maternal and newborn postnatal health checks before discharge compared to the effect of delivering in a government hospital. The indirect effects of delivering in private, CHAM, mission hospitals were also significantly lower on maternal postnatal health check before facility discharge but insignificant for newborn postnatal health check before facility discharge compared to the indirect effect of delivering in a government hospital.

For the total combined effects, delivering in government health centers, health posts and others had significantly lower effects on both maternal and newborn postnatal health checks before discharge compared to the effect of delivering in a government hospital. The total combined effects of delivering in private, CHAM or mission hospitals were significantly higher

on maternal and newborn postnatal health checks before discharge compared to the total combined effect of delivering in a government hospital.

A few other predictors in the model also showed statistically significant direct effects. The direct effects of receiving a cesarean section on maternal and newborn postnatal health checks before discharge were significantly higher compared to the effects of not receiving it. The direct effect of living in a rural area on newborn postnatal health check before discharge was significantly lower compared to the effect of living in an urban area. In addition, the direct effects of living in a northern region of the country on maternal and newborn postnatal health checks before discharge were significantly higher compared to the effects of living in a central region. The direct effect of living in a southern region on newborn postnatal check before discharge was significantly lower compared to the effect of living in a central region.

As for education, the direct effects of having had secondary education on maternal and newborn postnatal checks before discharge were significantly higher compared to the effects of having had no education. The direct effects of age, number of births and newborn size were not statistically significant. Lastly, the correlation between the errors of maternal and newborn postnatal health checks before discharge was high and statistically significant (See Table 12).

In order to provide a meaningful way of interpreting the coefficients, model-implied predicted probabilities were calculated for women with no education, between the ages 25 and 34, with four or more births, living in rural areas and living in the central region of the country. For these women, the model-implied predicted probability of receiving maternal postnatal check before facility discharge was: 48.88% if women delivered in a government hospital without cesarean section and 58.86% with cesarean section; 50.56% if women delivered in a government

health center, government health post or others without cesarean section and 60.53% with cesarean section; 58.71% if women delivered in a private, CHAM or mission hospital without cesarean section and 68.19% with cesarean section; 53.78% if women delivered in a CHAM health center, BLM or others without cesarean section and 63.61% with cesarean section. Model-implied predicted probabilities of receiving newborn postnatal check before facility discharge were also calculated for women with no education, who had an average-sized newborn, living in rural areas and living in the central region of the country: 67.40% if women delivered in a government hospital without cesarean section and 71.67% with cesarean section; 64.99% if women delivered in a government health center, government health post or others without cesarean section and 69.36% with cesarean section; 74.60% if women delivered in a private, CHAM or mission hospital without cesarean section and 78.35% with cesarean section; 71.67% if women delivered in a CHAM health center, BLM or others without cesarean section and 75.65% with cesarean section (See Table 13).

Discussion

In Malawi, there has been a major shift in trend of where women deliver (2). In the past few decades, the percentage of women delivering in health facilities has sharply increased to the point where 9 out of 10 women now deliver in health facilities (2). This is a promising trend as it implies that women can be expected to receive skilled maternity services during delivery and immediately after birth. The WHO recommends that all mothers and newborns delivering at the health facilities receive a timely postnatal health check before they are discharged to return home (14). Considering that over 90% of Malawian pregnant women now deliver in health facilities (2), the general population of new mothers would receive at least one professional health check

after birth if all health facilities followed WHO guidelines for PNC. Findings of this study indicate that this is not the case.

Across all public and private health facilities, the percentages of women receiving a postnatal health check ranged between a low of 42% and a high of 60%. The percentages of newborns receiving a postnatal health check ranged between 64% and 77%. This could perhaps be an indication that mothers compared to their newborns tend to be neglected for care after delivery, which calls for further investigation. Aside from the fact that mothers receive less attention at the health facilities in the postnatal period compared to the attention that newborns receive, the percentages showed that too many mothers and newborns are being missed before discharge across the board. This is a concern especially for government health facilities as the majority of Malawian women who deliver in facilities used either government hospitals or government health centers. Only a small percentage of these women used private services. This implies that government-affiliated health facilities should be the main target for interventions in order to have a wide coverage of pregnant women and newborns. The primary focus should be on ensuring that all women and newborns receive a postnatal health check before leaving the facilities in which they delivered.

Findings from the simultaneous equations model corroborate the need for such an intervention focus. Delivering in private, CHAM or mission hospitals had significantly higher direct and total effects on both maternal and newborn postnatal checks before discharge compared to the effects of delivering in government hospitals. Delivering in government health centers, health posts and others had significantly lower total effects on maternal and newborn postnatal checks before discharge compared to the effects of delivering in government hospitals. There were also some noticeable differences in the model-implied predicted probabilities by type

of health facility where women delivered. These could all be indications that the amount of postnatal attention women and newborns receive may depend on the established practices and protocols that are unique to the type of health facility where women deliver. It is also likely that patient volume affects the quality of care that patients receive. In either case, this is concerning as the same standard of PNC should apply to all women and newborns without conditional priority. Differences in PNC practice at the facility level could largely be due to differences in standards of care and patient volume between public and private facilities and between higher- and lower-level facilities within the same type of managing authority (public or private).

Kruk et al., in their recent study examining quality of basic maternal care functions in health facilities of five African countries (Kenya, Namibia, Rwanda, Tanzania and Uganda), found that quality of basic maternal care functions was significantly lower for primary care facilities compared to secondary care facilities (71). In addition, for both primary care and secondary care facilities, private facilities had significantly higher quality of basic maternal care functions compared to public facilities (71). Another finding of importance was that low volume of delivery was negatively associated with quality of basic maternal care functions for both primary care and secondary care facilities (71). The authors speculated that in an environment where there is low frequency of delivery and complications, providers may have difficulty retaining necessary clinical skills (71). Quality of basic maternal care functions was constructed as an index of 12 items including those related to facility infrastructure and care practices for normal and emergency situations (71). Although Malawi was not one of the countries examined in the study, it may exhibit similar facility care patterns that were described in the study as these countries are clustered in a similar geographic region.

On average, receiving cesarean section during delivery was also positively associated with maternal and newborn postnatal health checks before discharge, which again calls into question whether the same standard of PNC is being applied across the health facilities, mainly hospitals and a few health centers, that are performing cesarean section. In addition, across the different types of health facilities where women delivered, the model-implied predicted probabilities of maternal postnatal health check before discharge were about 10 percentage points higher for women who received cesarean section compared to those who did not. The model-implied predicted probabilities of newborn postnatal health check before discharge were about 4 percentage points higher for women who received cesarean section compared to those who did not. This calls for a re-examination of PNC strategies and protocols at the health facility level. It would also be important to make sure that providers do not consider PNC as only necessary when there is a complication. Refresher trainings on providing universal and quality preventative PNC may be helpful.

In addition, task-shifting to lower-level health workers could be an effective short-term strategy as facilities are under-staffed (59) and providers are over-burdened by the existing workload (59) and demotivated by the lack of organizational-level accountability, support and incentive structures (51). In the event where mothers and/or newborns show danger signs, lower-level health workers can alert higher-level providers for further care. In the longer term, it is pivotal for facilities and district managements to reform staff accountability and incentive structures so that the fundamental concerns related to human resources can be addressed.

As for the indirect effects via cesarean section, they were mostly significant and negative because while the effects of cesarean section on maternal and newborn postnatal checks were positive, the effects of delivering in government health centers, government health posts and

private health facilities on receipt of cesarean section were significantly lower than the effects of delivering in government hospitals (See Appendix Table 2). This is reasonable as cesarean section is primarily done in hospital settings and not in health centers or health posts in Malawi (45). The percentage of women reporting to have received cesarean section in either health centers or health posts was only 12.6% (not shown in tables).

It is also important to note that women's age, number of births and newborn size did not have statistically significant direct effects, with cesarean section specified as a mediated pathway in the model. This could perhaps suggest that more than these maternal and newborn characteristics themselves, receipt of cesarean section was a stronger predictor of whether women and newborns received postnatal health checks before discharge.

Interestingly, the direct effects of having had secondary education were significantly higher on maternal and newborn postnatal checks before discharge compared to the effects of having had no education. Such finding is difficult to understand as receipt of maternal and newborn postnatal checks before facility discharge should theoretically be a function of the care practices at the health facilities and not of the patients. This finding suggests, however, that women's level of education does play a part in whether mothers and newborns receive postnatal checks before facility discharge. It is possible that more educated women who may have knowledge of the importance of PNC or may belong in social groups where PNC is the norm, ask to be checked before discharge if the facility providers do not seem to initiate. However, this is only speculation and further research should look into the reasons why this may be the case.

Delivering at a health facility has clear advantages over delivering at home in low-resource settings (72). One of the main advantages is that being in a health facility gives women

and newborns an opportunity to receive skilled care during delivery and be professionally examined for any unexpected danger signs that might arise in the immediate postnatal period (72). However, it is a fallacy to assume that increases in facility delivery by default correlate with increases in coverage of timely PNC for both mothers and newborns. Increases in the public's demand for facility delivery should be met with provision of quality health services not only for delivery but also for the time period following immediately afterwards. Preventative health services with life-saving potential should also be provided equitably across all types and levels of health facilities, both public and private. Women and their newborns should not be receiving inconsistent quality and standards of PNC because they chose or happened to deliver in a certain type of health facility.

Special attention should also be given to rural areas of Malawi as living in rural areas was negatively associated with newborn postnatal health check before discharge compared to living in urban areas. The key objective is to encourage all health facilities to provide quality preventative postnatal health checks to all delivering women and their newborns before discharge as a regular protocol no matter the patients' actual or perceived need of greater care.

This study is not without limitations. A noteworthy limitation is that the current simultaneous equations model does not take into account potential measurement error. This is not so much of a problem for most of the variables in the model as it is clear what they are trying to measure and the distinction between categories is obvious. However, newborn size is a variable that could potentially suffer from measurement error, thereby biasing its coefficients and standard errors and perhaps contaminating others in a setting that utilizes the full information of the data simultaneously for estimation. In addition, receipt of cesarean section may not be a great proxy measure of complicated cases or high-risk scenarios as the likelihood of receiving

cesarean section is systematically different based on the type of health facility where women delivered. In other words, complicated deliveries in health centers or clinics may not have been well represented by the proxy measure compared to the complicated deliveries in hospitals. Another limitation is that the individual R-square values for the three equations were not too high. This could perhaps suggest that receipt of maternal and newborn postnatal health checks at the delivering health facility are influenced by more detailed facility-level and provider-level characteristics that are not in the dataset. It is also likely that having a measure for women's knowledge regarding the importance of PNC could help. Future research should explore this area further and improve upon this limitation.

Conclusion

The trend has shifted towards facility delivery in Malawi (2). This has significant public health implications for women and newborns as being in the facility presents an opportunity to receive timely and skilled PNC. Health facilities should revisit their current PNC strategies and protocols to examine if providers are following WHO guidelines (14). Task-shifting to lower-level health workers and addressing more fundamental problems related to human resources should also be considered. The goal is to have all women and newborns delivering at the facilities checked without conditionality before being discharged to return home.

Ethics Approval

This study was reviewed and exempted from ethics approval by the Institutional Review Board at the University of North Carolina at Chapel Hill.

Table 8. Coverage of maternal and newborn postnatal health checks before facility discharge, MDHS 2015-16

	Total	
	N	%
Maternal postnatal health check before facility discharge		
No	6558	53%
Yes	5867	47%
Newborn postnatal health check before facility discharge		
No	3967	32%
Yes	8334	68%

Note.

Population-weighted counts of women who gave birth in the past 5 years were reported from the MDHS 2015-16

Column percentages sum to 100%

Table 9. Descriptive information about the study variables, MDHS 2015-16

	Total	
	N	%
Type of health facility where women delivered		
Government hospital	3801	31%
Government health center/ health post/others	6904	56%
private/CHAM/mission hospital	1087	9%
CHAM health center/blm/others	634	5%
Cesarean section		
No	11569	93%
Yes	856	7%
Age		
15-24	4732	38%
25-34	5405	44%
35-49	2287	18%
Education		
No education	8414	68%

Primary education	3024	24%
Secondary education	987	8%
Household Wealth		
Poorest	2822	23%
Poorer	2663	21%
Middle	2374	19%
Richer	2277	18%
Richest	2290	18%
Number of births		
1	3126	25%
2-3	4640	37%
4+	4658	37%
Residence		
Urban	1866	15%
Rural	10558	85%
Region of the country		
Northern	1462	12%
Central	5230	42%
Southern	5732	46%
Newborn size		
Very large	1190	10%
Larger than average	3189	26%
Average	6089	49%
Smaller than average	1365	11%
Very small	512	4%

Note.

Population-weighted counts of women who gave birth in the past 5 years were reported from the MDHS 2015-16

The totals were based on observations who either received maternal postnatal health check before discharge or not (weighted total = 12,424)

Column percentages sum to 100%

Table 10. Type of health facility where women delivered stratified by maternal and newborn postnatal health check before health facility discharge in Malawi, MDHS 2015-16

	Maternal postnatal health check before facility discharge				Newborn postnatal health check before facility discharge			
	Yes		No		Yes		No	
	N	%	N	%	N	%	N	%
Type of health facility where women delivered	***				***			
Government hospital	2002	53%	1799	47%	2703	72%	1049	28%
Government health center/ health post/others	2912	42%	3992	58%	4364	64%	2493	36%
private/CHAM/mission hospital	652	60%	435	40%	827	77%	242	23%
CHAM health center/blm/others	302	48%	332	52%	439	71%	183	29%

Note.

***p<0.001

Row percentages sum to 100%

The weighted totals were 12,424 for maternal postnatal health check before discharge and 12,301 for newborn postnatal health check before discharge

Table 11. Tests for model specification

	Test results	Indication of good model fit
Diagonally-weighted least squares chi-square test		
Test statistic	16.020	
Degrees of freedom	16	P-value > 0.05
P-value	0.4516	
Tucker-Lewis Index (TLI)	1.000	TLI = 1 is ideal; TLI > 0.95 is acceptable
Incremental Fit Index (IFI)	1.000	IFI = 1 is ideal; IFI > 0.95 is acceptable
Relative Noncentrality Index (RNI)	1.000	RNI = 1 is ideal; RNI > 0.95 is acceptable
Root Mean Square Error of Approximation (RMSEA)	0.0003	RMSEA = 0 is ideal; RMSEA < 0.06 is acceptable
BIC test	-135.008	BIC < 0

Note.

The incremental fit index (IFI), relative noncentrality index (RNI) and BIC were calculated by hand. Overall chi-square test, Tucker-Lewis index (TLI) and root mean square error of approximation (RMSEA) were a part of the Mplus output.

Table 12. The total, direct and indirect effects of key predictors on maternal and newborn postnatal health checks before health facility discharge in Malawi, MDHS 2015-16

	Maternal postnatal health check before facility discharge		Newborn postnatal health check before facility discharge	
	Coef	Std Error	Coef	Std Error
Type of health facility where women delivered				
Total Effects:				
Government hospital (ref)	-	-	-	-
Government health center/health post/others	-0.226***	0.043	-0.197***	0.048
private/CHAM/mission hospital	0.200**	0.071	0.187*	0.080
CHAM health center/blm/others	-0.079	0.079	0.024	0.082
Direct Effects:				
Government hospital (ref)	-	-	-	-
Government health center/health post/others	0.043	0.054	-0.067	0.067
private/CHAM/mission hospital	0.248***	0.070	0.210**	0.080
CHAM health center/blm/others	0.123	0.079	0.122	0.090
Indirect Effects (via cesarean section):				
Government hospital (ref)	-	-	-	-
Government health center/health post/others	-0.269***	0.033	-0.130**	0.039
private/CHAM/mission hospital	-0.048*	0.021	-0.023	0.012
CHAM health center/blm/others	-0.203***	0.046	-0.098**	0.033
Cesarean section				
No (ref)	-	-	-	-
Yes	0.253***	0.027	0.122**	0.036
Age				
15-24 (ref)	-	-	-	-
25-34	0.015	0.045	NA	NA
35-49	0.025	0.059	NA	NA
Education				
No education (ref)	-	-	-	-
Primary education	0.037	0.037	0.060	0.037
Secondary education	0.260***	0.070	0.185*	0.075
Number of births				
1 (ref)	-	-	-	-
2-3	0.056	0.042	NA	NA
4+	0.074	0.060	NA	NA
Residence				
Urban (ref)	-	-	-	-
Rural	-0.145	0.086	-0.190*	0.090
Region of the country				
Northern	0.271***	0.061	0.430***	0.068
Central (ref)	-	-	-	-

Southern	-0.076	0.053	-0.170**	0.052
Newborn size				
Very large	NA	NA	0.046	0.054
Larger than average	NA	NA	0.026	0.041
Average (ref)	-	-	-	-
Smaller than average	NA	NA	0.045	0.047
Very small	NA	NA	0.016	0.086
	Estimate		Std Error	
Covariance of the errors of maternal postnatal health check and newborn postnatal health check	0.728***		0.016	
	R-square estimates		Thresholds	
Maternal postnatal health check	0.117		-0.026	
Newborn postnatal health check	0.084		-0.641***	
Cesarean section	0.249		1.318***	

Note.

*p<0.05 **p<0.01 ***p<0.001

There were 12,572 observations used for the analysis.

Probit regression coefficients and standard errors of the study variables are presented. The estimates were obtained in Mplus 8.1.

Total effects were calculated as the sum of the direct effects and the indirect effects.

"NA" stands for not applicable. The corresponding variables were not included in the model for the particular outcome being predicted and therefore, no estimates were obtained.

The opposite sign of the threshold value is the intercept (i.e. the intercepts for maternal postnatal health check and newborn postnatal health check are 0.026 and 0.641 respectively).

Table 13. Model-implied predicted probabilities for maternal postnatal health check and newborn postnatal health check by type of health facility where women delivered and receipt of cesarean section

	Maternal postnatal health check before facility discharge				Newborn postnatal health check before facility discharge			
	No cesarean section		Cesarean section		No cesarean section		Cesarean section	
Type of health facility where women delivered:	XB	Prob	XB	Prob	XB	Prob	XB	Prob
Government hospital	-0.028	0.4888	0.224	0.5886	0.451	0.6740	0.573	0.7167
Government health center/ health post/others	0.014	0.5056	0.267	0.6053	0.385	0.6499	0.506	0.6936
Private/CHAM/ mission hospital	0.220	0.5871	0.473	0.6819	0.662	0.7460	0.784	0.7835
CHAM health centers/blm/others	0.095	0.5378	0.348	0.6361	0.573	0.7167	0.695	0.7565

Note.

Model-implied predicted probabilities ("Prob") were calculated using the probit regression coefficients and the reported threshold values for reference. Threshold values with the opposite signs were used as intercepts.

Model-implied predicted probabilities ("Prob") for maternal postnatal health check were calculated for a woman who has no education, in the age group 25-34, with four or more births, living in rural areas and in the central region.

Model-implied predicted probabilities ("Prob") for newborn postnatal health check were calculated for a woman who has no education, had a newborn with average size, living in rural areas and in the central region.

CHAPTER 4. CONCLUSION

Implications for Programs and Policies

The majority of rural women in Malawi live within 10 km of a health facility that provides PNC services. In addition, health facilities located beyond 10 km of where women live did not show significant effects on maternal or newborn PNC. Hence, the construction of new facilities in order to increase PNC service coverage may not be cost-efficient. Alternatively, existing clinic-level facilities and health centers that currently do not provide PNC should be supported to provide quality PNC for mothers and newborns. For lower-level health facilities that already provide PNC, quality improvement strategies could be considered as clinic-level facilities providing PNC did not show significant effects on maternal or newborn PNC. Three essential components required for such an upgrade of services are: (1) clearly describing preventative maternal and newborn PNC as a part of the essential health package in the Malawi HSSP II; (2) training all health providers based in lower-level facilities to be able to perform quality PNC services; and (3) ensuring a system of staff support, accountability, feedback, supervision and incentives at the organizational level. Health providers should also advise women on the importance of PNC to encourage timely use of services after discharge from the facility. Arranging home visits with health workers affiliated with nearby facilities can also be considered to increase care options for women based on their needs and preferences.

Increasing the availability and quality of PNC services across clinic-level facilities and health centers can potentially bring at least two positive effects. First, it can lessen the workload of overburdened staff at hospitals and other tertiary-level facilities because more primary-level facilities will now be on the frontline of providing quality preventative PNC services. Second, increases in the availability of health facilities providing quality PNC near residential communities may generally encourage more women to receive PNC services regardless of where they delivered. However, it is also paramount to understand women's other personal motivations or reasons for why they might or might not use PNC services.

For women who deliver at health facilities specifically, it would be important to ensure that the same standard of quality PNC is provided at all types and affiliations of health facilities. The findings showed that the effects of delivering in private hospitals on maternal and newborn PNC before facility discharge were significantly higher than the effect of delivering in government hospitals. Receiving cesarean section during delivery was also a positive predictor.

As the WHO recommendations note, all women and newborns must receive a postnatal check-up before they are discharged from the health facility in which the women delivered. Receipt of cesarean section or any other maternal and newborn characteristics should not be factors in deciding whether women and newborns receive PNC before discharge. In addition, there should not be a public perception that different types and affiliations of health facilities have different protocols or standards for providing PNC. Coverage of PNC before facility discharge should be universal. The same program strategies mentioned above can be used in this case as well. See Figure 5 for a visual summary of the key program strategies and recommendations.

Implications for Future Research

Although the findings of this dissertation offer valuable insight into the current state of PNC service delivery in Malawi, much research remains to be done in this area of study. A few quantitative and qualitative research ideas can be used to supplement this dissertation as a follow up effort. First, further quantitative work can look at the effects of public and private health facilities within a certain distance band on maternal and newborn PNC use. While this study was able to look at the effects of clinic-level facilities, health centers and hospitals on maternal and newborn PNC for three distance bands, it was not able to tease apart the various affiliations of the health facilities. Health facilities in Malawi are largely managed by the government, private organizations, CHAM, NGOs and others (45). Due to having a large number of facility indicators in the models already, adding more indicators by differentiating facility types by affiliations was not deemed ideal for analysis of the first paper. However, future work can perhaps choose one distance band (within 5 km or within 10 km) and further tease apart the affiliations of each facility type present within the specified distance band.

Second, it would also be interesting if the geographic locations of women's delivering facilities can be linked with the detailed facility surveys. This would allow for detailed facility-level characteristics to also be included in analysis models predicting maternal and newborn PNC use at the individual level. Such models may help improve the low R-square value for newborn PNC in the second paper and make the analysis richer. With the current DHS data structure, however, this linkage procedure cannot be done as the names of the facilities where women delivered are not kept in the dataset and therefore, linking them with the geographic locations and with the SPA survey is impossible. Original study designs and primary datasets are needed to pursue this work.

Third, qualitative studies could bring more in-depth understanding of health providers' perceptions and opinions on: (1) what PNC means to them; (2) what should be done during PNC for women and newborns; (3) who should receive PNC after delivery; (4) routine PNC practices that they perform at their facilities; (5) routine practices that they see their peers performing at their facilities; and (6) whether they think there are discrepancies between what is considered routine at the facility and what is considered best practices. Qualitative research techniques such as in-depth interviews, focus groups and direct observations can be used to investigate these important questions.

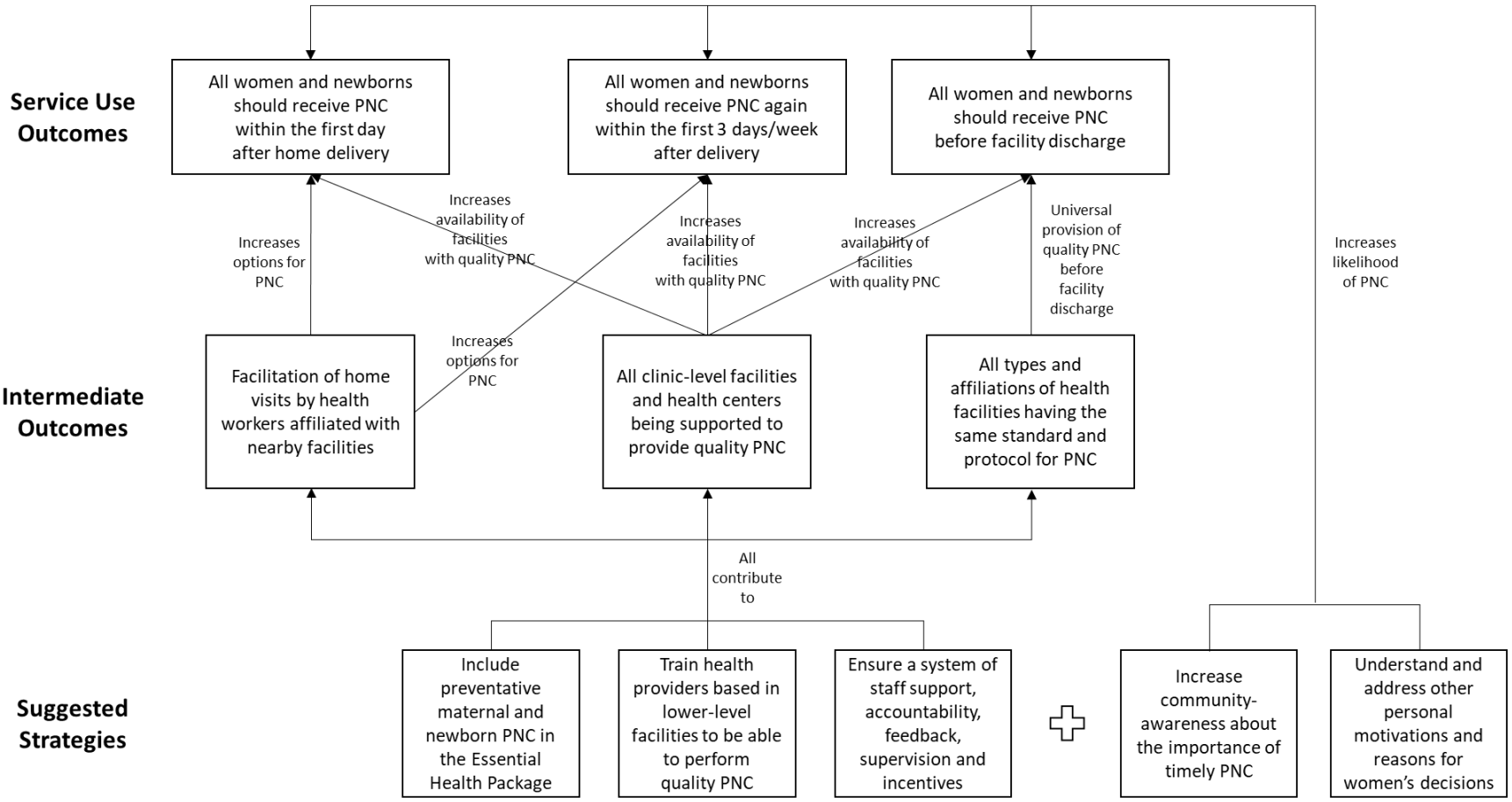
Women should also be interviewed about: (1) their thoughts on the importance of PNC services; (2) when they think they should seek PNC services; (3) whether they have preferences for certain type and/or affiliation of health facilities for PNC; (4) their past experiences with PNC services; and (5) whether they are aware of nearby primary-level facilities that provide PNC services and why they would or would not use them.

Conclusion

The majority of Malawian women now deliver in health facilities (2). This presents special opportunities not only for skilled delivery but also for skilled and timely PNC. For facility deliveries, all women and newborns should be receiving quality PNC before discharge. In addition, all clinics and health centers should be equipped to provide quality PNC services for women delivering at home and also for women seeking additional visits after being discharged from the facility. Lastly, increasing community-awareness about the importance of timely PNC and about the utility of lower-level facilities for quality preventative PNC would be important. Future research should consider incorporating more detailed facility-level data and investigating

provider and patient perceptions regarding PNC services. PNC is a strategic intervention that is designed to minimize preventable maternal and newborn deaths (10). It deserves greater focus and continued attention by policymakers, donors, academic researchers, program decision-makers, health providers and local communities.

Figure 5. Overview of Key Program Strategies and Recommendations



APPENDIX

Appendix Table 1. The effects of different types and proximities of health facilities on maternal/newborn PNC within 1 day among rural women who gave birth at health facilities in Malawi, MDHS 2015-16

	Maternal		Newborn	
	PNC within 1 day		PNC within 1 day	
	DE	[95% CI]	DE	[95% CI]
Type and Proximity of Health Facilities				
Within 5 km of household cluster				
Clinic-level				
No facility (ref)	-	-	-	-
Facility	0.014	[-0.004, 0.033]	0.003	[-0.013, 0.018]
Health center				
No facility (ref)	-	-	-	-
Facility	-0.003	[-0.011, 0.005]	-0.002	[-0.009, 0.006]
Hospital				
No facility (ref)	-	-	-	-
Facility	-0.02*	[-0.034, -0.004]	-0.007	[-0.018, 0.005]
Between 5 km and 10 km of household cluster				
Clinic-level				
No facility (ref)	-	-	-	-
Facility	0.004	[-0.007, 0.015]	0.006	[-0.004, 0.015]
Health center				
No facility (ref)	-	-	-	-
Facility	0.000	[-0.009, 0.010]	0.000	[-0.008, 0.008]
Hospital				
No facility (ref)	-	-	-	-
Facility	-0.002	[-0.011, 0.007]	-0.004	[-0.012, 0.003]
Between 10 km and 15 km of household cluster				
Clinic-level				
No facility (ref)	-	-	-	-

	Facility	-0.009	[-0.019, 0.001]	-0.004	[-0.012, 0.004]
Health center					
	No facility (ref)	-	-	-	-
	Facility	-0.006	[-0.015, 0.003]	-0.000	[-0.010, 0.009]
Hospital					
	No facility (ref)	-	-	-	-
	Facility	-0.008	[-0.017, 0.001]	-0.009*	[-0.017, -0.001]

Note.

*p<0.05

Total number of women who received maternal PNC is 10,231; Total number of newborns who received PNC is 10,173;
Number of observations for maternal outcomes is 10,083; Number of observations for newborn outcomes is 10,029

The outcomes were Maternal PNC within 1 day or Newborn PNC within 1 day in two separate GEE models

The main predictors (separate binary indicators) in the GEE models were whether or not there was: a clinic-level facility providing PNC within 5 km; a health center providing PNC within 5 km; a hospital providing PNC within 5 km; a clinic-level facility providing PNC between 5 km and 10 km; a health center providing PNC between 5 km and 10 km; a hospital providing PNC between 5 km and 10 km; a clinic-level facility providing PNC between 10 km and 15 km; a health center providing PNC between 10 km and 15 km; a hospital providing PNC between 10 km and 15 km

Covariates included in the GEE models were season in which women gave birth, ownership of TV or radio, whether cost of treatment is a perceived problem, women's age, women's education, women's employment, household wealth, number of births, newborn size, newborn sex, religion, region, cesarean section and whether or not the mother or the newborn (depending on the outcome) was checked before discharge from facility

Appendix Table 2. The effects of key predictors on receipt of cesarean section in Malawi, MDHS 2015-16

	Receipt of cesarean section	
	Coef	Std Error
Type of health facility where women delivered		
Government hospital (ref)	-	-
Government health center/health post/others	-1.064***	0.062
private/CHAM/mission hospital	-0.192*	0.081
CHAM health center/blm/others	-0.803***	0.157
Age		
15-24 (ref)	-	-
25-34	0.192**	0.073

	35-49	0.312**	0.103
Education			
	No education (ref)	-	-
	Primary education	0.008	0.064
	Secondary education	0.101	0.091
Household wealth			
	Poorest	0.042	0.076
	Poorer	0.025	0.072
	Middle (ref)	-	-
	Richer	0.220**	0.076
	Richest	0.210*	0.091
Number of births			
	1 (ref)	-	-
	2-3	-0.110	0.065
	4+	-0.459***	0.095
Residence			
	Urban (ref)	-	-
	Rural	0.121	0.077
Region of the country			
	Northern	0.213**	0.066
	Central (ref)	-	-
	Southern	-0.065	0.056
Newborn size			
	Very large	0.360***	0.076
	Larger than average	0.261***	0.060
	Average (ref)	-	-
	Smaller than average	0.017	0.083
	Very small	0.022	0.126

Note.

*p<0.05 **p<0.01 ***p<0.001

There were 12,572 observations used for the analysis. For more detail on the model, see Table 12.

Probit regression coefficients and standard errors of the study variables are presented. The estimates were obtained in Mplus 8.1.

REFERENCES

1. The World Bank. Malawi Overview [Internet]. The World Bank in Malawi. 2018 [cited 2019 Feb 18]. Available from: http://www.worldbank.org/en/country/malawi/overview#1

2. National Statistical Office (NSO) [Malawi], ICF International. Malawi Demographic and Health Survey 2015-16 [Internet]. Zomba, Malawi, and Rockville, Maryland, USA; 2017. Available from: http://dhsprogram.com/pubs/pdf/FR319/FR319.pdf

3. Malawi Ministry of Health. Health Sector Strategic Plan II (2017-2022). Government of the Republic of Malawi. 2017.

4. WHO, UNICEF, UNFPA, World Bank Group, United Nations Population Division. Trends in Maternal Mortality: 1990 to 2015. Geneva, Switzerland; 2015.

5. WHO, UNICEF, UNFPA, World Bank Group, United Nations Population Division Maternal Mortality Estimation Inter-Agency Group. Maternal mortality in 1990-2015 [Internet]. World Health Organization. [cited 2017 Dec 7]. Available from: http://www.who.int/gho/maternal_health/countries/mwi.pdf

6. World Health Organization. Neonatal and Perinatal Mortality: Country, Regional and Global Estimates. Geneva, Switzerland; 2006.

7. World Health Organization. Global Health Observatory (GHO) data: Neonatal mortality situation and trends [Internet]. WHO. World Health Organization; 2017 [cited 2017 Dec 6]. Available from: http://www.who.int/gho/child_health/mortality/neonatal_text/en/

8. UNICEF, World Health Organization, World Bank Group, United Nations. Levels and Trends in Child Mortality Report 2015. 2015.

9. Say L, Chou D, Gemmill A, Tunçalp Ö, Moller A-B, Daniels J, et al. Global causes of maternal death: a WHO systematic analysis. Lancet Glob Heal. 2014;2:e323–33.

10. The Partnership for Maternal N and CH. Opportunities for Africa's newborns: Practical data, policy and programmatic support for newborn care in Africa [Internet]. WHO. World Health Organization; 2006 [cited 2017 Dec 7]. Available from: http://www.who.int/pmnch/media/publications/africanewborns/en/

11. Salam RA, Mansoor T, Mallick D, Lassi ZS, Das JK, Bhutta ZA. Essential childbirth and postnatal interventions for improved maternal and neonatal health. Reprod Health. 2014;11(Suppl 1):S3.

12. World Health Organization. Newborns: reducing mortality [Internet]. WHO. World Health Organization; 2017 [cited 2017 Dec 7]. Available from: http://www.who.int/mediacentre/factsheets/fs333/en/

13. WHO Guidelines Review Committee. Guidelines on Maternal, Newborn, Child and Adolescent Health: Recommendations on Newborn Health [Internet]. [cited 2017 Dec 7]. Available from: http://www.who.int/maternal_child_adolescent/documents/guidelines-recommendations-newborn-health.pdf

14. World Health Organization. Postnatal Care for Mothers and Newborns: Highlights from the World Health Organization 2013 Guidelines [Internet]. Maternal and Child Survival Program. 2015 [cited 2017 Dec 7]. Available from: http://www.who.int/maternal_child_adolescent/publications/WHO-MCA-PNC-2014-Briefer_A4.pdf

15. Singh K, Brodish P, Haney E. Postnatal care by provider type and neonatal death in sub-Saharan Africa: a multilevel analysis. BMC Public Health. 2014;14(941).

16. Tarekegn SM, Lieberman LS, Giedraitis V. Determinants of maternal health service utilization in Ethiopia: analysis of the 2011 Ethiopian Demographic and Health Survey. BMC Pregnancy Childbirth. 2014;14(161).

17. Somefun OD, Ibisomi L. Determinants of postnatal care non-utilization among women in Nigeria. BMC Res Notes. 2016;9(21).

18. Phiri PWC, Rattanapan C, Mongkolchati A. Determinants of postnatal service utilisation among mothers in rural settings of Malawi. Heal Soc Care Community. 2015;23(5):493–501.

19. Mohan D, Gupta S, Lefevre A, Bazant E, Killewo J, Baqui AH. Determinants of postnatal care use at health facilities in rural Tanzania: multilevel analysis of a household survey. BMC Pregnancy Childbirth. 2015;15(282).

20. Babalola S, Fatusi A. Determinants of use of maternal health services in Nigeria - looking beyond individual and household factors. BMC Pregnancy Childbirth. 2009;9(43).

21. Ononokpono DN, Odimegwu CO, Imasiku ENS, Adedini SA. Does it really matter where women live? A multilevel analysis of the determinants of postnatal care in Nigeria. Matern Child Health J. 2014;18:950–9.

22. Worku AG, Yalew AW, Afework MF. Factors affecting utilization of skilled maternal care in Northwest Ethiopia: a multilevel analysis. BMC Int Health Hum Rights. 2013;13(20).

23. Dahiru T, Oche OM. Determinants of antenatal care, institutional delivery and postnatal care services utilization in Nigeria. Pan Afr Med J. 2015;21(321).

24. Cronin CJ, Guilkey DK, Speizer IS. The individual's choice of facility for maternal health and family planning services in a dense urban environment: the case of Senegal. SSRN [Internet]. 2016; Available from: http://dx.doi.org/10.2139/ssrn.2848295

25. Kruk ME, Mbaruku G, McCord CW, Moran M, Rockers PC, Galea S. Bypassing primary care facilities for childbirth: a population-based study in rural Tanzania. Health Policy Plan [Internet]. 2009;24(4):279–88. Available from: https://academic.oup.com/heapol/article-lookup/doi/10.1093/heapol/czp011

26. Kruk ME, Hermosilla S, Larson E, Mbaruku GM. Bypassing primary care clinics for childbirth: a cross-sectional study in the Pwani region, United Republic of Tanzania. Bull World Health Organ [Internet]. 2014;92:246–53. Available from: http://www.who.int/bulletin/volumes/92/4/13-126417/en/

27. Shah R. Bypassing birthing centres for child birth: a community-based study in rural Chitwan Nepal. BMC Health Serv Res [Internet]. 2016;16(597). Available from: http://download.springer.com/static/pdf/925/art%253A10.1186%252Fs12913-016-1848-x.pdf?originUrl=http%3A%2F%2Fbmchealthservres.biomedcentral.com%2Farticle%2F10.1186%2Fs12913-016-1848-x&token2=exp=1491961663~acl=%2Fstatic%2Fpdf%2F925%2Fart%25253A10.1186%252

28. Kanté AM, Exavery A, Phillips JF, Jackson EF. Why women bypass front-line health facility services in pursuit of obstetric care provided elsewhere: a case study in three rural districts of Tanzania. Trop Med Int Heal. 2016;21(4):504–14.

29. Kruk ME, Paczkowski M, Mbaruku G, de Pinho H, Galea S. Women's Preferences for Place of Delivery in Rural Tanzania: A Population-Based Discrete Choice Experiment. Am J Public Health. 2009;99(9):1666–72.

30. Akin JS, Hutchinson P. Health-care facility choice and the phenomenon of bypassing. Health Policy Plan. 1999;14(2):135–51.

31. Somefun OD, Ibisomi L. Determinants of postnatal care non-utilization among women in Nigeria. BMC Res Notes. 2016;9(21).

32. Thaddeus S, Maine D. TOO FAR TO WALK: MATERNAL MORTALITY IN CONTEXT. Soc Sci Med. 1994;38(8):1091–110.

33. Gabrysch S, Campbell OM. Still too far to walk: Literature review of the determinants of delivery service use. BMC Pregnancy Childbirth [Internet]. 2009 [cited 2017 Dec 7];9(34). Available from: http://www.biomedcentral.com/1471-2393/9/34

34. United Nations. Sustainable Development Goals - 17 goals to transform our world [Internet]. United Nations. 2015 [cited 2017 May 4]. Available from: http://www.un.org/sustainabledevelopment/health/

35. International Monetary Fund. Malawi Economic Development Document. IMF Country Report. 2017.

36. Organisation for Economic Co-operation and Development (OECD). DEVELOPMENT AID AT A GLANCE: STATISTICS BY REGION: 2. AFRICA [Internet]. 2018. Available from: http://www.oecd.org/dac/financing-sustainable-development/

37. Kinney M V, Kerber KJ, Black RE, Cohen B, Nkrumah F, Coovadia H, et al. Sub-Saharan Africa's Mothers, Newborns, and Children: Where and Why Do They Die? PLoS Med. 2010;7(6):e1000294.

38. Strasser R. Rural health around the world: challenges and solutions. Fam Pract. 2003;20(4):457–63.

39. Strasser R, Kam SM, Regalado SM. Rural Health Care Access and Policy in Developing Countries. Annu Rev Public Health. 2016;37:395–412.

40. World Health Organization. Achieving the health-related MDGs. It takes a workforce! [Internet]. Health workforce. World Health Organization; 2010 [cited 2018 Sep 7]. Available from: http://www.who.int/hrh/workforce_mdgs/en/

41. World Health Organization. WHO recommendations on postnatal care of the mother and newborn. 2013.

42. Langlois É V, Miszkurka M, Zunzunegui MV, Ghaffar A, Ziegler D, Karp I. Inequities in postnatal care in low-and middle-income countries: a systematic review and meta-analysis. Bull World Heal Organ. 2015;93:259–70.

43. Burgert CR, Colston J, Roy T, Zachary B. Geographic Displacement Procedure and Georeferenced Data Release Policy for the Demographic and Health Surveys. Calverton, Maryland, USA; 2013.

44. Burgert CR, Prosnitz D. Linking DHS Household and SPA Facility Surveys: Data Considerations and Geospatial Methods [Internet]. Rockville, Maryland, USA; 2014. Available from: https://dhsprogram.com/pubs/pdf/SAR10/SAR10.pdf

45. Ministry of Health (MoH) [Malawi], ICF International. Malawi Service Provision Assessment (MSPA) 2013-14. Lilongwe, Malawi, and Rockville, Maryland, USA; 2014.

46. Skiles MP, Burgert CR, Curtis SL, Spencer J. Geographically linking population and facility surveys: methodological considerations. Popul Health Metr. 2013;11(14).

47. The DHS Program - Quality information to plan, monitor and improve population, health, and nutrition programs [Internet]. [cited 2017 Dec 7]. Available from: https://dhsprogram.com/

48. Gunasekara FI, Carter K, Blakely T. Glossary for econometrics and epidemiology. J Epidemiol Community Heal. 2008;62(10):858–61.

49. Hubbard AE, Ahern J, Fleischer NL, Van Der Laan M, Satariano SA, Jewell N, et al. To GEE or Not to GEE: Comparing Population Average and Mixed Models for Estimating the Associations Between Neighborhood Risk Factors and Health. Epidemiology. 2010;21(4):467–74.

50. STATA. Margins documentation [Internet]. stata.com. [cited 2018 Jun 22]. Available from: https://www.stata.com/manuals13/rmargins.pdf

51. Djellouli N, Mann S, Nambiar B, Meireles P, Miranda D, Barros H, et al. Improving postpartum care delivery and uptake by implementing context-specific interventions in four countries in Africa: a realist evaluation of the Missed Opportunities in Maternal and Infant Health (MOMI) project. BMJ Glob Heal. 2017;2(e000408).

52. Manafa O, McAuliffe E, Maseko F, Bowie C, MacLachlan M, Normand C. Retention of health workers in Malawi: perspectives of health workers and district management. Hum Resour Health. 2009;7(65).

53. Rowe AK, De Savigny D, Lanata CF, Victora CG. How can we achieve and maintain high-quality performance of health workers in low-resource settings? Lancet. 2005;366:1026–35.

54. Hurst TE, Semrau K, Patna M, Gawande A, Hirschhorn LR. Demand-side interventions for maternal care: Evidence of more use, not better outcomes. BMC Pregnancy Childbirth. 2015;15(297).

55. Munthali AC, Mannan H, MacLachlan M, Swartz L, Makupe CM, Chilimampunga C. Non-use of Formal Health Services in Malawi: Perceptions from Non-users. Malawi Med J. 2014;26(4):126–32.

56. Abiiro GA, Mbera GB, De Allegri M. Gaps in universal health coverage in Malawi: A qualitative study in rural communities. BMC Health Serv Res. 2014;14(234).

57. Kambala C, Morse T, Masangwi S, Mitunda P. Barriers to maternal health service use in Chikhwawa, Southern Malawi. Malawi Med J. 2011;23(1):1–5.

58. Kumbani LC, Chirwa E, Malata A, Odland JØ, Bjune G. Do Malawian women critically assess the quality of care? A qualitative study on women's perceptions of perinatal care at a district hospital in Malawi. Reprod Health. 2012;9(30).

59. Bradley S, Kamwendo F, Chipeta E, Chimwaza W, De Pinho H, McAuliffe E. Too few staff, too many patients: a qualitative study of the impact on obstetric care providers and on quality of care in Malawi. BMC Pregnancy Childbirth. 2015;15(65).

60. Nambiar B, Hargreaves DS, Morroni C, Heys M, Crowe S, Pagel C, et al. Improving health-care quality in resource-poor settings. Bull World Heal Organ. 2017;95:76–8.

61. Franco LM, Bennett S, Kanfer R. Health sector reform and public sector health worker motivation: a conceptual framework. Soc Sci Med. 2002;54:1255–66.

62. Stanton C. Steps towards achieving skilled attendance at birth. Bull World Health Organ. 2008;86(4).

63. Sibley LM, Sipe TA. Transition to Skilled Birth Attendance: Is There a Future Role for Trained Traditional Birth Attendants? J Heal Popul NUTR. 2006;24(4):472–8.

64. World Health Organization. Skilled attendants at birth (Global Health Observatory data) [Internet]. WHO. World Health Organization; 2018 [cited 2018 Sep 21]. Available from: http://www.who.int/gho/maternal_health/skilled_care/skilled_birth_attendance_text/en/

65. Chinkhumba J, De Allegri M, Muula AS, Robberstad B. Maternal and perinatal mortality by place of delivery in sub-Saharan Africa: a meta-analysis of population-based cohort studies. BMC Public Health. 2014;14(1014).

66. Doctor H V, Nkhana-Salimu S, Abdulsalam-Anibilowo M. Health facility delivery in sub-Saharan Africa: successes, challenges, and implications for the 2030 development agenda. BMC Public Health. 2018;18(765).

67. Winship C, Mare RD. Structural Equations and Path Analysis for Discrete Data. Am J Sociol [Internet]. 1983 [cited 2019 Feb 13];89(1):54–110. Available from: https://www.jstor.org/stable/2779048

68. Brito C, Pearl J. A new identification condition for recursive models with correlated errors. Struct Equ Model. 2002;9(4):459–74.

69. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Model A Multidiscip J. 1999;6(1):1–55.

70. Bollen KA, Harden JJ, Ray S, Zavisca J. BIC and Alternative Bayesian Information Criteria in the Selection of Structural Equation Models. Struct Equ Model A Multidiscip J. 2014;21(1):1–19.

71. Kruk ME, Leslie HH, Verguet S, Mbaruku GM, Adanu RMK, Langer A. Quality of basic maternal care functions in health facilities of five African countries: an analysis of national health system surveys. Lancet Glob Heal. 2016;4:e845-55.

72. The Partnership for Maternal N& CH. Opportunities for Africa's Newborns: Practical data, policy and programmatic support for newborn care in Africa. 2006.