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When Connectivity Reaches Care: Internet Diffusion, Rural Inequality and Maternal Healthcare in Sub-Saharan Africa

Laura Gerda Bluemink

la3042bl-s@student.lu.se

Supervisor: Olof Ejermo

Examiner: Alexandra L. Cermeño

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Despite rapid improvements in digital connectivity across Sub-Saharan Africa, little is known about whether broader internet diffusion influences maternal healthcare behavior outside targeted digital health interventions. This thesis examines whether internet diffusion is associated with maternal healthcare utilization, and whether these associations differ between urban and rural populations. Using individual birth histories from the Demographic and Health Surveys combined with country-level indicators of internet diffusion, submarine cable connectivity and macroeconomic development across twelve Sub-Saharan African countries, the study applies fixed-effects regression models, heterogeneity analyses and robustness checks. The results show that higher internet diffusion is positively associated with maternal healthcare utilization, particularly facility-based delivery. These associations are strongest among rural women, suggesting that digital connectivity may be especially relevant in settings where informational barriers are greater. Evidence for antenatal care is less consistent, and no meaningful association is found for infant mortality. The findings highlight the potential role of digital infrastructure in supporting more inclusive healthcare access and development.

Keywords: Internet diffusion, Maternal healthcare, Sub-Saharan Africa, Digital infrastructure, Urban-rural inequalities

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List of abbreviations

WHO	World Health Organization
DHS	Demographic and Health Surveys
ICT	Information and Communication Technologies
ANC	Antenatal Care
ANC4+	Antenatal Care, four or more visits
SEACOM	Submarine cable network connecting Eastern and Southern Africa
EASSy	Eastern Africa Submarine System
DiD	Difference-in-Differences

1. Introduction

1.1 Maternal health in a rapidly digitizing region

For many women in Sub-Saharan Africa, the decision of where and when to seek care during pregnancy can have life-changing consequences. While childbirth-related mortality has declined globally over recent decades, maternal and neonatal health outcomes remain among the region's most persistent development challenges (WHO, 2025). A large share of maternal deaths could be prevented through timely access to antenatal care, skilled birth attendance and emergency obstetric services. Yet access to these services remains uneven, particularly in settings where healthcare infrastructure is limited and reaching formal care requires substantial time, resources or information.

Over the same period, Sub-Saharan Africa has undergone a major transformation in digital connectivity. Beginning in the late 2000s, the arrival of international submarine fiber-optic cables significantly expanded internet capacity across many African countries, reducing communication costs and accelerating internet adoption (Goldfarb & Tucker, 2019). As digital technologies became increasingly integrated into daily life, access to information, communication and public services began to change in ways that extended beyond markets and businesses.

This raises an important question in development research. While the economic effects of digital infrastructure are increasingly well documented, less is known about whether these same improvements in connectivity influence behavior in other welfare-relevant domains. In the context of maternal healthcare, access to information may play an important role in how women make decisions during pregnancy and childbirth.

1.2 Context and motivation

Maternal healthcare decisions are often made under conditions of uncertainty. Women may need to evaluate pregnancy risks, compare care options, identify available services or decide whether the benefits of seeking professional care outweigh the financial, geographic or social costs

involved. In many low-resource settings, these decisions are shaped not only by household resources or service availability, but also by access to reliable information.

This is particularly relevant in Sub-Saharan Africa, where infrastructure development has historically been uneven across regions (OECD & African Union Commission, 2025). Urban areas tend to have substantial concentration of healthcare services, educational opportunities and communication networks, while rural populations often face greater physical and informational barriers. As a result, changes in digital access may have different implications depending on local conditions and existing access to alternative sources of information.

From this perspective, internet diffusion may function as more than a technological change. By lowering information frictions, expanding communication networks and increasing exposure to health-related knowledge, digital connectivity may influence whether and how women engage with formal maternal healthcare services.

1.3 Academic gap, aim and contribution

A growing body of literature has documented the developmental effects of digital technologies in low- and middle-income countries. Studies in development economics show that improvements in information and communication technologies (ICT), including mobile phones and broadband internet, can reduce information frictions, improve market efficiency, stimulate employment and support broader economic development (Cariolle, 2021; Hjort & Poulson, 2019; Simione & Li, 2021, pp.6-7). At the same time, maternal health research has consistently shown that access to information, healthcare infrastructure and socioeconomic resources strongly influence the use of antenatal care, skilled birth attendance and facility-based delivery in Sub-Saharan Africa (Campbell & Graham, 2006; Mekonnen et al., 2019; Dahab & Sakellariou, 2020). Taken together, these findings suggest that access to information and communication technologies may play an important role in shaping health-related decision-making.

Despite these advances, the connection between these two strands of literature remains relatively underexplored. Existing ICT research has largely focused on economic outcomes such as labor markets, firm productivity, education and agricultural development. Where health has been considered, studies have mainly examined targeted digital interventions, including mobile

messaging campaigns, telemedicine services or health-specific applications. While these studies demonstrate the potential of digital technologies in healthcare settings, they provide limited evidence on whether broader population-level internet diffusion influences routine maternal healthcare behavior outside intervention-based contexts.

Conversely, the maternal healthcare literature has extensively examined the socioeconomic, geographic and cultural barriers that shape women's healthcare utilization, but has paid relatively limited attention to how changing digital information environments may influence maternal health decision-making. This gap is particularly relevant in Sub-Saharan Africa, where maternal health inequalities remain substantial and where the rapid expansion of submarine fiber-optic infrastructure has fundamentally transformed access to digital connectivity.

Against this background, the aim of this study is to examine whether internet diffusion is associated with maternal healthcare utilization in Sub-Saharan Africa, and whether this relationship differs between urban and rural women. Investigating this distinction is particularly relevant in Sub-Saharan Africa, where disparities in healthcare access and digital connectivity between urban and rural areas remain substantial, as will be discussed further in the literature review.

This thesis contributes to the literature in three ways. First, it connects the ICT and development literature to maternal healthcare utilization by examining whether country-level internet diffusion is associated with individual maternal healthcare behaviors, including facility-based delivery and antenatal care utilization. Second, it introduces a geographic heterogeneity perspective by examining whether these associations vary between urban and rural populations, recognizing that the value of digital information may depend on existing access to healthcare services and alternative information channels. Third, by combining macro-level indicators of digital infrastructure with micro-level Demographic and Health Survey (DHS) data across multiple Sub-Saharan African countries, this study provides new evidence on how broad technological diffusion may influence maternal health decision-making in resource constrained settings.

1.4 The research question

To examine whether internet diffusion is associated with maternal healthcare utilization in Sub-Saharan Africa, and whether this relationship differs between urban and rural populations, the following research question is proposed.

To what extent is internet diffusion associated with maternal healthcare utilization, and how do these associations differ between urban and rural populations in Sub-Saharan Africa?

To answer this question, the study combines individual birth histories from the DHS with country-level indicators of internet diffusion, submarine cable connectivity and macroeconomic development across twelve Sub-Saharan African countries. Maternal healthcare utilization is examined through facility-based delivery, antenatal care utilization and completion of at least four antenatal visits, which reflects the minimum level of antenatal care previously recommended by the World Health Organization (WHO). Infant mortality is additionally included as a secondary outcome.

1.5 Scope and structure

This study focuses on twelve coastal Sub-Saharan African countries for which comparable data on maternal health outcomes, internet adoption and submarine cable connectivity are available (see chapter 3.1 and appendix table B1 for the full sample). By observing birth cohorts before and after major expansions in digital infrastructure, the analysis examines how changes in national digital environments relate to maternal healthcare behavior over time.

The analysis is organized as follows. Chapter 2 reviews the relevant literature and develops the theoretical framework and hypotheses that follow. Chapter 3 describes the data and variable construction. Chapter 4 presents the empirical methodology. Chapter 5 reports the main findings, followed by robustness analyses in Chapter 6. Chapter 7 discusses the findings in light of the theoretical background. Chapter 8 dives into the limitations of the study and propositions for future research. The final chapter concludes.

2. Literature Review

2.1 Maternal healthcare utilization in Sub-Saharan Africa

Maternal and neonatal health remain central public health challenges in low- and middle-income countries, particularly in Sub-Saharan Africa. Despite significant global reductions in maternal mortality over recent decades, the region continues to account for a disproportionate share of maternal deaths. According to estimates by the World Health Organization (2025, p.35; WHO Regional Office of Africa, 2025), maternal mortality in the African region declined by approximately 40 percent between 2000 and 2023, from 727 to 442 deaths per 100 thousand live births. Despite this progress, of the approximately 92 percent of global maternal deaths in low- and middle-income countries in 2023, Sub-Saharan Africa includes 70 percent of this total. This accounts for 182 thousand deaths and means that the region remains far from achieving the Sustainable Development Goal target of reducing maternal mortality to fewer than 70 deaths per 100 thousand live births by 2030. The WHO (2025) further emphasizes that most maternal deaths are preventable through timely access to quality obstetric care, skilled birth attendance and adequate antenatal and postnatal services.

One of the most widely studied indicators of maternal healthcare utilization is facility-based delivery. This is generally defined as childbirth taking place in a formal health institution with skilled birth attendants present and access to basic equipment to deal with routine deliveries and additional care (Zenbaba et al., 2021; Dudley, 2018). Existing evidence shows that facility delivery is associated with reductions in maternal complications, improved emergency referral possibilities and lower neonatal mortality risk (Campbell & Graham, 2006). The World Health Organization (2004) further emphasizes that access to skilled birth attendance during childbirth is one of the most important interventions for preventing maternal and newborn deaths, particularly in low-resource settings where complications during delivery can become life-threatening without timely medical care. Consequently, in situations where complications during childbirth remain unpredictable, access to institutional care is therefore often considered one of the most effective mechanisms for reducing preventable maternal and infant deaths.

In addition to delivery care, antenatal care (ANC) plays an essential role in maternal health outcomes. ANC visits allow healthcare providers to detect pregnancy-related complications, provide nutritional counseling, administer vaccinations and prepare mothers for childbirth. Earlier guidelines from the World Health Organization recommended a minimum of four antenatal visits, while more recent guidelines recommend eight contacts during pregnancy (WHO, 2016a, pp.101-104). Nevertheless, coverage remains challenging across many African countries, particularly in rural and underserved populations (p.121).

A vast body of literature has examined determinants of maternal healthcare utilization in developing countries. Gabrysch and Campbell (2009) find that the factors consistently associated with higher use of maternal services include maternal education, literacy, household wealth, geographic accessibility, media exposure and urban residence. At the same time, barriers such as transportation constraints, limited autonomy in household decision-making, financial costs and lack of health knowledge continue to reduce utilization rates. Dahab and Sakellariou (2020) also highlight, in their systematic review examining 13 high-quality papers on the barriers of seeking maternal health care in Africa, that financial constraints, long travel distances, limited transportation infrastructure and shortages of healthcare facilities remain major obstacles to maternal care utilization. In addition, sociocultural factors such as low female autonomy, limited education, traditional beliefs and lack of health information may further discourage women from seeking professional maternal care. These barriers are often particularly severe in rural areas, where healthcare access and information availability tend to be more limited.

2.2 Theoretical frameworks of healthcare utilization

To understand why some women seek maternal healthcare while others do not, this study draws on Andersen's updated Behavioral Model of Health Services Use from 1968. Andersen (1968 cited in Andersen, 1995) proposes that healthcare utilization is influenced by three groups of factors, namely predisposing factors, enabling factors and need factors (Andersen, 1995, figure 1).

Although Andersen's Behavioral Model was originally developed in 1968 and later revised in 1995, it remains a widely used theoretical framework in health services research and continues to be frequently applied in studies on healthcare utilization in low- and middle-income countries. For

example, recent research by Baten et al. (2025) applies Andersen's model to examine maternal healthcare utilization in low- and middle-income settings, highlighting the continued relevance of factors such as education, wealth, place of residence and access-related constraints in shaping maternal healthcare behavior. The model's enduring applicability stems from its broad and flexible structure, which allows researchers to examine how socioeconomic characteristics, access-related constraints and healthcare needs jointly shape healthcare-seeking behavior.

Predisposing factors refer to individual characteristics that shape healthcare behavior, such as age, education, social norms and cultural beliefs. Need factors relate to perceived or actual health conditions that generate demand for medical care. However, maternal healthcare decisions are often not determined by medical need alone. Bloom, Lippeveld and Wypij (1999) show that maternal healthcare utilization is also influenced by women's knowledge, perceptions of pregnancy risk and broader social circumstances that shape care-seeking behavior. This suggests that even when the need for care exists, women may not necessarily seek professional healthcare services. The ability to translate healthcare needs into actual service utilization often depends on enabling factors, which capture the practical resources and conditions that make healthcare access possible.

Within maternal and child health research in low- and middle-income countries, evidence consistently suggests that enabling factors play a particularly important role in shaping healthcare utilization. While women may recognize the importance of antenatal care or skilled birth attendance, actual service use is often constrained by geographic distance, physical infrastructure, financial barriers, service availability, limited autonomy in household decision-making and poor access to health information (Dahab & Sakellariou, 2020; Gabrysch & Campbell, 2009). As discussed in 2.1, Gabrysch and Campbell (2009) show in their systematic review of delivery service utilization in developing countries, that geographic accessibility, household resources and maternal education are among the strongest predictors of facility-based delivery, and Dahab and Sakellariou (2020) add to this by studying the geographic, financial and sociocultural barriers to seeking institutional care. Studies from Sub-Saharan Africa further show that rural women living farther from health facilities or transport infrastructure were significantly less likely to use antenatal and delivery care services (Dotse-Gborgbortsi et al., 2020; Ayele et al., 2025).

These findings suggest that in many low-income settings, maternal healthcare utilization is often limited less by the recognition of medical need and more by the ability to convert that need into actual healthcare use. Building on this literature, the present study conceptualizes internet access as a modern enabling resource. By expanding access to information, reducing search costs and potentially improving awareness of available services, internet connectivity may reduce informational barriers that traditionally limit maternal healthcare utilization.

2.3 Infrastructure, information access and development

Infrastructure has long been recognized as a driver of economic and social development (Gurara et al., 2017; Gorgulu et al., 2023, pp.43-44). Traditional infrastructure such as roads, electricity and telecommunications can reduce transaction costs, improve market integration and expand access to public services (Calderón & Servén, 2010). More recently, digital infrastructure has emerged as an increasingly important determinant of development outcomes (Gorgulu et al., 2023, pp.7-14).

Cariolle (2021) examines the direct effect of submarine cable deployment on internet penetration and the digital divide in Sub-Saharan Africa. Using difference-in-differences estimations for 45 Sub-Saharan African countries between 1990 and 2014, the author finds that the rollout of the SEACOM and EASSy submarine cables in 2009–2010 increased internet penetration rates in Eastern and Southern Africa by approximately 3–5 percentage points relative to the rest of the continent. These findings suggest that submarine cable expansion played an important role in accelerating digital connectivity across the region and support the idea that cable arrival can serve as a meaningful proxy for broader changes in the information environment.

In its turn, the spread of internet connectivity has significantly transformed access to information across low- and middle-income countries. By reducing the cost of acquiring information, facilitating communication and expanding access to markets, education and public services, digital infrastructure has shown itself to be an increasingly important factor of development (Goldfarb & Tucker, 2019; Gorgulu et al., 2023, pp.11-12). From an economic perspective, the potential role of internet access can be understood through information asymmetry (Akerlof, 1970). In many markets, including healthcare, individuals often make decisions under conditions of incomplete

information. Patients may possess less information than healthcare providers regarding health risks, available services or appropriate treatment options. Such informational disadvantages can reduce healthcare utilization or lead to delayed care-seeking behavior. In the context of maternal healthcare, women may lack information about the importance of antenatal care, the risks associated with home delivery or the availability of healthcare services nearby. By improving access to timely and relevant information, digital technologies may help reduce these asymmetries, increase awareness of maternal health risks and available services and support more informed healthcare decisions during pregnancy and childbirth.

The importance of information access through digital technologies is also highlighted in earlier ICT research. In a study of mobile phone adoption among fishermen in Kerala, India, Jensen (2007) demonstrates that improved communication technology reduced information asymmetries between markets, lowered inefficiencies and generated persistent welfare gains through higher producer profits and lower consumer prices. Jensen's findings show that in environments characterized by imperfect information, digital technologies can fundamentally alter how individuals access, process and act upon economically relevant information.

Evidence from Sub-Saharan Africa suggests that these effects extend beyond communication alone and may generate broader economic and social change. Using the staggered arrival of submarine fiber-optic cables along Africa's coast, Hjort and Poulsen (2019a) show that improved access to fast internet causally increased employment rates in connected regions across twelve African countries. Their findings suggest that digital infrastructure contributed to job creation not only by increasing internet adoption, but also by stimulating firm entry, raising productivity among existing firms and facilitating export activity. Importantly, the authors argue that fast internet can contribute to structural economic transformation in developing economies by improving access to information and lowering barriers to participation in higher-productivity economic activities.

While both Hjort and Poulsen (2019a) and Jensen (2007) focus primarily on labor markets and economic behavior, the underlying mechanisms are highly relevant for healthcare decision-making in low-income settings. Similar to workers or firms operating under informational constraints, pregnant women in resource-constrained environments often make maternal healthcare decisions under conditions of incomplete information, uncertainty and high search costs. Information

regarding pregnancy risks, available services, facility quality or the benefits of skilled birth attendance may not be readily accessible through traditional channels. In this context, internet access may function as an enabling resource by reducing informational barriers, improving health knowledge and facilitating more informed maternal healthcare utilization.

2.4 Internet access and health behavior

The literature increasingly recognizes that digital technologies can influence health-related behavior through several complementary mechanisms. In the context of maternal healthcare, internet access may affect not only the information available to women, but also how they interpret health risks, evaluate available services and make care-seeking decisions during pregnancy and childbirth.

First, internet access may improve health literacy, defined as an individual's capacity to obtain, process and understand health information needed to make appropriate health decisions (Nutbeam, 2000). In the context of pregnancy, greater access to health information may help women recognize danger signs, understand the benefits of antenatal care and skilled birth attendance, and prepare more effectively for childbirth. Recent literature on digital health in Sub-Saharan Africa suggests that mobile and internet-based tools may create new opportunities for health education and service access, particularly as mobile coverage expands. However, these benefits are not automatic. Ouedraogo et al. (2023) emphasize that digital health tools remain limited when users lack the skills, connectivity, electricity or understanding needed to use them effectively, and argue that digital health literacy is essential for inclusive digital health provision in Sub-Saharan Africa. Similarly, van Kessel et al. (2022) conceptualize digital health literacy as a broader determinant of health, highlighting that access to digital health information only becomes meaningful when individuals can find, understand, evaluate and apply it. This is particularly relevant for the present study, as internet diffusion may affect maternal healthcare behavior not simply by increasing information availability, but by changing women's ability to access and act upon health-related knowledge.

Second, digital connectivity may facilitate social learning and behavioral diffusion. According to Social Learning Theory, individuals often form beliefs and adopt behaviors by observing others

within their social environment (Bandura, 1977). The spread of mobile internet, messaging platforms and online social networks may expand women's exposure to peer experiences. Evidence from low- and middle-income countries suggests that sociocultural beliefs, perceptions of service quality and prior delivery experiences strongly influence women's decisions to seek facility-based care (Gabrysch & Campbell, 2009). Observing positive experiences with facility-based delivery or antenatal care among peers may reduce uncertainty and increase trust in formal healthcare services. Social learning mechanisms may be particularly relevant in maternal healthcare settings, where care-seeking decisions are often embedded in community norms, family expectations and previous experiences with healthcare providers.

Third, internet access may reduce search costs, defined in economics as the time, effort and resources required to obtain relevant information before making decisions. In markets characterized by imperfect information (discussed in section 2.3), digital technologies can lower these costs by making information easier to access and compare (Bakos, 1997). Alongside maternal healthcare information itself, search costs may include identifying nearby facilities, understanding available maternal services, learning clinic opening hours or assessing provider quality. These informational frictions may be particularly relevant in low-resource settings, where healthcare systems are often fragmented and formal information channels are limited. As healthcare decisions are also characterized by information asymmetries between providers and patients (Akerlof, 1970), improved digital access may help women make more informed maternal healthcare decisions by reducing uncertainty and facilitating earlier contact with professional care providers.

Empirical evidence on the relationship between digital connectivity and health outcomes remains mixed. A review by Kreps and Neuhauser (2010) argues that digital communication technologies have considerable potential to improve health communication, patient engagement and access to health information, but that their effectiveness depends heavily on existing infrastructure, literacy levels and the institutional quality of healthcare systems. These findings are in line with the barriers discussed above. More broadly, studies in digital health suggest that changes in information access may first affect intermediate behaviors, such as knowledge acquisition, care-seeking or service utilization, before translating into final health outcomes such as maternal or infant mortality, which

are additionally influenced by healthcare quality, provider availability and broader public health conditions.

2.5 Urban-rural inequalities in digital access and healthcare

Access to maternal healthcare remains highly unequal between urban and rural populations in many low- and middle-income countries. A large body of maternal health literature shows that women living in rural areas are less likely to use antenatal care, skilled birth attendance and facility-based delivery services than women living in urban areas (Gabrysch & Campbell, 2009; Dotse-Gborgbortsi et al., 2020; Ayele et al., 2025). These differences are commonly explained by greater geographic distance to health facilities, weaker transportation infrastructure, lower educational attainment, lower household resources and more limited exposure to formal health information channels (Gabrysch & Campbell, 2009; National Research Council., 2003, pp.42-45, 212-217). In addition, perceptions of service quality, previous community experiences with healthcare providers and local social norms may further influence care-seeking behavior in rural settings, where alternative sources of information are often more limited (Bandura, 1977).

A similar spatial inequality exists in access to digital infrastructure. Internet adoption in Sub-Saharan Africa has historically been concentrated in urban and economically connected regions, where infrastructure deployment is more financially viable due to higher population density and stronger market demand. Research on digital infrastructure expansion in Africa shows that access to fast internet initially benefited locations connected to backbone infrastructure and coastal landing points, highlighting how geography continues to shape digital inclusion (Hjort & Poulsen, 2019a; Cariolle, 2021). As a result, rural populations often face a double disadvantage. Namely, lower access to both healthcare services and the digital tools that may facilitate access to those services.

At the same time, these initial disadvantages may imply that the marginal benefits of internet access are larger in rural settings. Rural populations often face weaker physical infrastructure, fewer formal information channels and greater geographic isolation, which increases the costs of obtaining relevant information and accessing services. Research on rural digital development shows that digital technologies may help compensate for these structural disadvantages by

expanding access to information and services in underserved areas (Salemink et al., 2017). From an economic perspective, this can be understood through the logic of diminishing marginal returns. Individuals who already have access to multiple sources of information (e.g., through clinics, schools, media or dense social networks) may experience smaller incremental gains from additional digital access, whereas populations facing informational scarcity may benefit more strongly from new access to information. This mechanism is consistent with economic theories of search costs, which emphasize that digital technologies generate the greatest value in environments where information acquisition is initially costly or constrained (Bakos, 1997). Recent evidence further suggests that internet-enabled health services can improve health opportunities among rural women by reducing informational and access barriers (Jia et al., 2024).

This argument is also consistent with broader development literature on technological leapfrogging, which suggests that low-income populations may adopt newer technologies in ways that partially compensate for missing traditional infrastructure (Steinmueller, 2001). In rural African contexts, digital connectivity may therefore serve not only as a communication technology, but also as an alternative channel for accessing health information where formal information systems remain weak or geographically inaccessible.

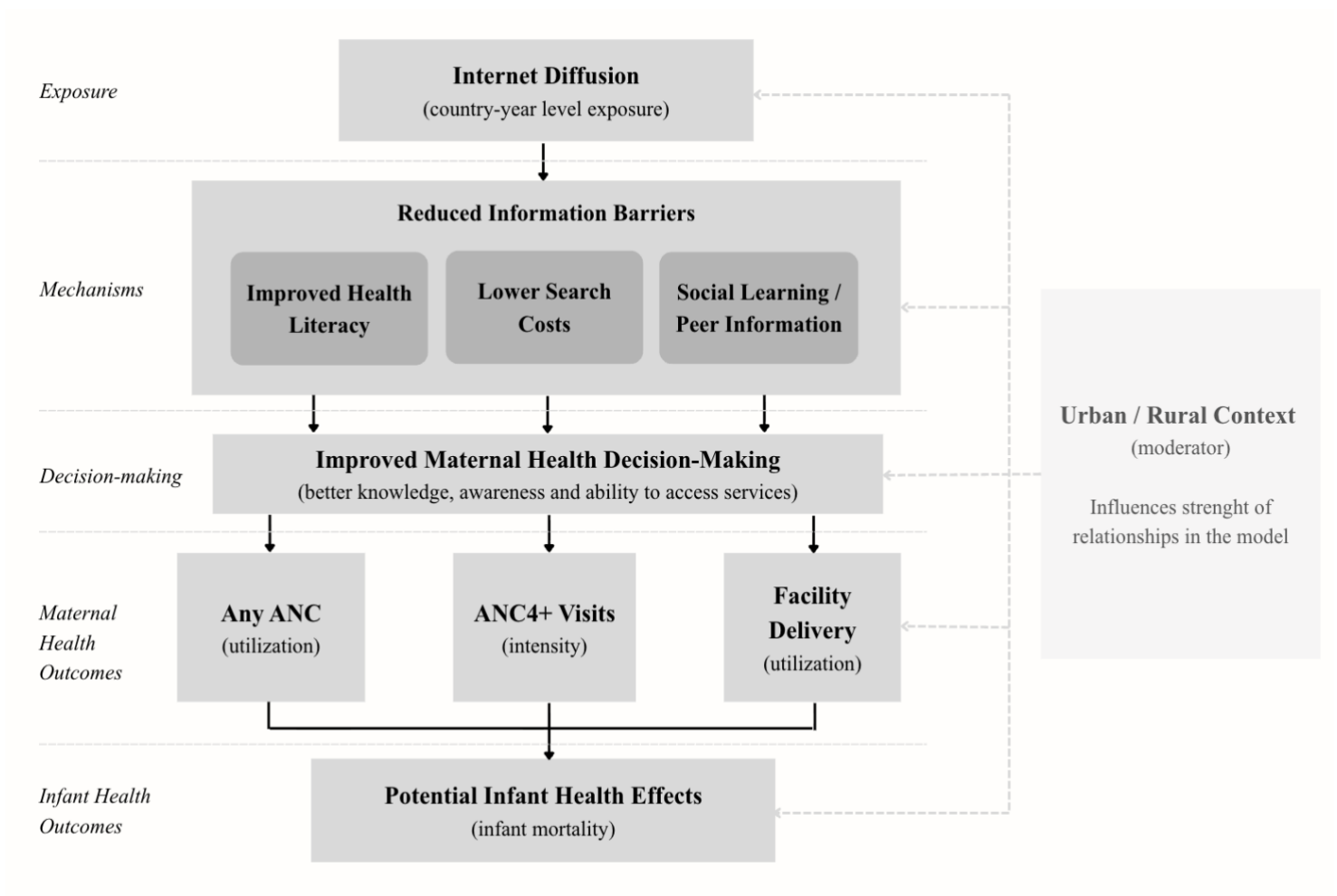
2.6 Conceptual framework

Drawing on the theoretical and empirical literature discussed above, figure 1 presents the conceptual framework underlying this study. Internet diffusion is expected to influence maternal healthcare utilization through several related mechanisms, including improved health literacy, reduced search costs and increased opportunities for social learning. These mechanisms may affect women's maternal healthcare decisions, including antenatal care use and facility-based delivery. While the empirical analysis accounts for baseline differences across countries and populations through fixed effects and individual-level control variables, the framework further suggests that the association between internet diffusion and maternal healthcare utilization may differ between urban and rural women. This is because digital connectivity may interact differently with existing healthcare access, infrastructure and information environments across geographic settings.

The framework additionally recognizes that changes in maternal healthcare utilization may contribute to broader infant health outcomes, particularly through improved antenatal care and

safer delivery conditions. At the same time, infant mortality is positioned as a secondary outcome because it is influenced by a much wider range of factors beyond maternal healthcare-seeking behavior alone.

Figure 1: Internet diffusion and maternal health model



2.7 Hypotheses

Based on the theoretical framework and literature, this study examines whether improvements in digital connectivity are associated with maternal healthcare behavior in Sub-Saharan Africa. Internet access may reduce informational barriers, facilitate access to relevant health information and support healthcare decision-making during pregnancy and childbirth.

The first hypothesis therefore tests whether greater internet diffusion is associated with increased maternal healthcare utilization:

H1: Higher levels of internet diffusion are positively associated with maternal healthcare utilization in Sub-Saharan Africa.

This relationship is examined through indicators of maternal care-seeking behavior, including facility-based delivery, antenatal care use and completion of recommended antenatal visits.

As access to healthcare services, formal information channels and digital infrastructure differs substantially between geographic populations, the effects of internet diffusion may not be equally distributed. Women in rural areas often face greater informational and physical barriers to care, which may increase the relative value of improved digital access. Although maternal healthcare utilization levels generally remain higher in urban areas, internet diffusion may generate larger marginal improvements in healthcare utilization among rural women if informational constraints are initially more severe.

This leads to the second hypothesis:

H2: The positive association between internet diffusion and maternal healthcare utilization is larger among rural women than among urban women.

Finally, this study explores whether changes in maternal healthcare behavior are also reflected in infant health outcomes. Infant mortality is included because improvements in antenatal care utilization and facility-based delivery are often associated with better maternal and newborn health outcomes in the broader maternal health literature (Campbell & Graham, 2006). At the same time, infant survival depends on a much wider set of factors beyond maternal healthcare-seeking

behavior alone, including healthcare quality, nutrition, sanitation, disease environment and postnatal care (WHO, 2016b). As a result, internet diffusion may be more likely to influence intermediate behavioral outcomes, such as maternal healthcare utilization, than final mortality outcomes directly. Infant mortality is therefore treated as a secondary and more exploratory outcome variable in this study.

The third hypothesis follows:

H3: Internet diffusion is associated with infant mortality outcomes alongside positive maternal healthcare utilization.

3. Data

3.1 Data sources and explanatory variables

This study combines individual-level health data with country-level indicators of internet diffusion, digital infrastructure and macroeconomic development across Sub-Saharan Africa.

The primary source of maternal and infant health data is the Demographic and Health Surveys, a nationally representative household survey program conducted across low- and middle-income countries. The specific DHS dataset references can be found in appendix B2. The Birth Recode datasets of the DHS provides detailed retrospective birth histories, measures of maternal healthcare utilization and socioeconomic characteristics of women of reproductive age (15–49 years). These data are particularly well suited for this study, as they allow the construction of birth-level observations that can be linked to maternal characteristics and healthcare outcomes across multiple survey waves and national contexts.

The sample consists of twelve Sub-Saharan African countries for which DHS birth histories could be successfully matched with data on internet diffusion and the timing of submarine fiber-optic cable arrival. To ensure sufficient variation for identifying changes before and after major digital infrastructure expansion, countries were included only if they are not landlocked and at least one DHS survey wave was available both prior to and following submarine cable connectivity. Based on these criteria, the final sample includes Benin, D.R. Congo, Ghana, Kenya, Madagascar, Mozambique, Namibia, Nigeria, Senegal, South Africa, Tanzania and Togo. Detailed information on survey coverage and cable landing dates is provided in appendix table B1.

To measure digital connectivity, country-level internet usage data were obtained from the World Bank (2026a), specifically the indicator “Individuals using the Internet (% of population).” This measure captures the share of a country’s population using the internet in a given year and serves as the primary proxy for internet diffusion throughout the analysis.

The use of country-year internet data reflects both conceptual and practical considerations. First, this study examines the broader diffusion of digital infrastructure and changes in national information environments following the expansion of submarine fiber-optic connectivity.

Country-level internet penetration therefore provides a relevant measure of how access to digital technologies evolves over time within each national context. Rather than capturing only individual internet adoption, it reflects broader changes in the availability, affordability and social diffusion of internet access that may influence health-related decision-making through information spillovers and changes in communication networks.

Second, while the DHS includes individual-level information on mobile phone ownership and internet use in some survey waves, these variables were introduced only in relatively recent years, largely after the arrival of submarine cable infrastructure, and contain substantial missing observations across countries and survey rounds. Using these variables as the primary measure of digital connectivity would therefore substantially reduce temporal coverage and eliminate much of the pre-treatment variation necessary for the longitudinal analysis conducted in this study. As shown in appendix table C2, observations for both variables begin only around 2006 and reveal considerable disparities in digital access between rural and urban women, particularly with regard to internet use.

For these reasons, country-level internet penetration offers the most consistent and comparable measure of digital diffusion across countries and over time, while preserving the ability to analyze changes before and after major infrastructure expansion.

To capture major infrastructure shocks in digital connectivity, this study follows the empirical approach developed by Hjort and Poulsen (2019a) in their analysis of fast internet expansion in Africa. Their study exploits the staggered arrival of international submarine fiber-optic cables along the African coast during the late 2000s and early 2010s as a source of variation in access to high-speed internet. Hjort and Poulsen show that the arrival of these cables substantially increased internet speeds and internet usage in connected regions, suggesting that submarine cable expansion represented a meaningful infrastructure shock to digital connectivity. Similar findings are reported by Cariolle (2021), who finds that the rollout of major submarine cables in Eastern and Southern Africa increased internet penetration at a higher rate relative to the rest of Sub-Saharan Africa.

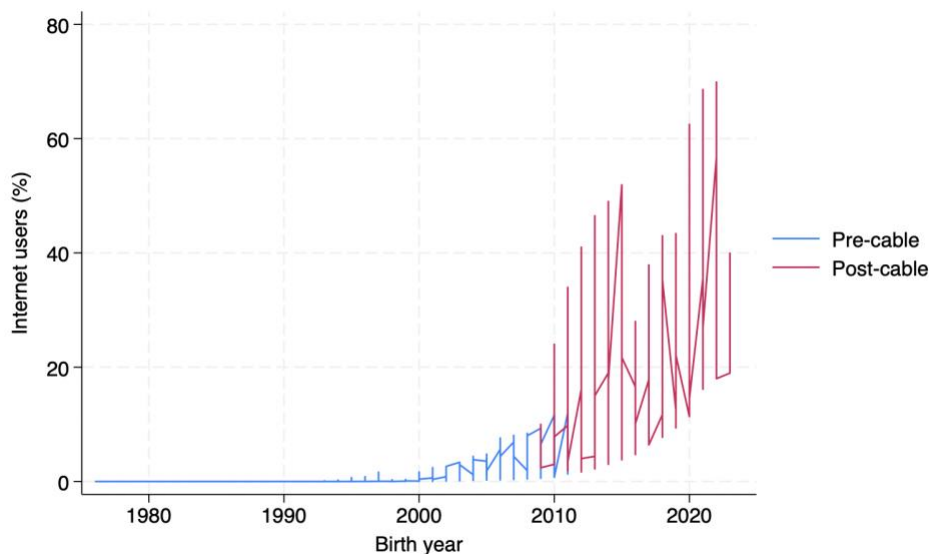
Building on this literature, information on submarine cable arrival dates was collected from the appendix information provided by Hjort and Poulsen (2019b). Based on these landing dates, a

binary treatment indicator was constructed that takes the value one for years following a country's connection to international submarine fiber-optic infrastructure, and zero otherwise.

The use of submarine cable arrival as a proxy for internet expansion is motivated by the fact that international fiber-optic connections substantially reduced bandwidth costs, increased internet speed and improved internet quality across many African countries during this period. While cable arrival does not directly measure individual internet adoption, it captures an important supply-side expansion in digital infrastructure that contributed to broader internet diffusion within national markets. In this sense, cable connectivity provides an infrastructure-based measure of exogenous improvements in the digital environment, complementing the observed country-level variation in internet penetration used throughout the main analysis.

Additional descriptive analysis further supports the use of submarine cable connectivity as a relevant proxy for broader digital expansion within the sample. Figure 2 illustrates average internet penetration before and after submarine cable arrival, showing a substantial increase in internet use following cable connectivity. Appendix table C1 reports a country fixed-effects regression without common year controls which shows that submarine cable arrival is associated with an average increase of approximately 17 percentage points in internet penetration within countries over time. However, once birth-year fixed effects are included, this relationship becomes substantially weaker and statistically insignificant, suggesting that much of the observed increase in internet use reflects broader continent-wide and global trends in digital expansion occurring during the same period. This finding supports the interpretation developed throughout the thesis that submarine cable arrival represents a broad enabling infrastructure shock, but may be too coarse to capture the gradual and uneven process through which meaningful household-level internet diffusion occurs.

Figure 2: Average internet diffusion before and after submarine cable arrival



Finally, macroeconomic (additional) controls, GDP per capita, health expenditure and urbanization rate, were obtained from the World Bank (*2026b; 2025a; 2026c*) to account for broader economic development trends that may simultaneously influence both digital adoption and maternal health outcomes.

3.2 Sample construction

The unit of observation in the final dataset is an individual birth reported by women interviewed in the DHS. As DHS birth histories are collected retrospectively, observations referring to births that occurred many years before the interview may be more susceptible to recall error, particularly for variables related to healthcare utilization, birth circumstances and child survival. To improve measurement reliability while maintaining sufficient temporal variation for the empirical analysis, the sample was restricted to births occurring within ten years prior to the survey year.

This restriction is particularly relevant given the longitudinal nature of the study, which examines changes in maternal healthcare behavior before and after major expansions in digital infrastructure. A ten-year observation window provides sufficient variation across birth cohorts while reducing the likelihood that reported outcomes are affected by inaccuracies in long-term retrospective reporting.

After applying this restriction, the sample covers births between 1976 and 2024. Following the merge with country-year indicators of internet diffusion, submarine cable connectivity and macroeconomic controls, the final pooled dataset contains more than a million birth-level observations across multiple countries and survey waves.

Yet, the effective estimation sample varies across empirical specifications due to differences in variable availability across DHS survey rounds. Appendix table C3 shows that maternal healthcare outcomes such as facility delivery and antenatal care utilization are not consistently collected in earlier survey waves. As a result, models including these variables are estimated on smaller subsamples than the full birth-history dataset. However, these subsamples continue to provide substantial temporal coverage, including multiple birth cohorts observed both before the arrival of submarine cable infrastructure and prior to the rapid expansion of internet adoption in the sample countries. The maternal healthcare outcomes are largely available from 1985 onwards. This preserves sufficient pre-treatment variation for meaningful comparison over time.

3.3 Outcome variables

This study focuses on both maternal healthcare utilization outcomes and infant health outcomes gathered from the DHS.

3.3.1 Facility delivery

The primary maternal healthcare outcome is facility-based delivery, measured as a binary indicator equal to one if a child was delivered in a formal health facility (e.g., hospital, clinic, health center), and zero otherwise.

Facility delivery is chosen as a primary outcome because it directly reflects maternal healthcare utilization at childbirth and is strongly associated with access to skilled birth attendance, emergency obstetric care and improved maternal and neonatal outcomes (*Gabrysch & Campbell, 2009*).

Facility delivery is chosen as the primary outcome because it directly reflects maternal healthcare utilization at childbirth and is widely regarded as one of the most important interventions for

reducing maternal and neonatal mortality. Existing literature shows that facility-based delivery is strongly associated with access to skilled birth attendance, emergency obstetric care and improved maternal and neonatal outcomes (Campbell & Graham, 2006; Gabrysch & Campbell, 2009). The World Health Organization (2004) further emphasizes that skilled care during childbirth is critical for preventing maternal and newborn deaths, particularly in low-resource settings where delivery complications can rapidly become life-threatening without timely medical intervention.

3.3.2 Antenatal care utilization

Two measures of antenatal healthcare utilization are included. The first, Any ANC, is a binary indicator equal to one if the mother reported receiving at least one antenatal care visit during pregnancy. This measure captures initial contact with formal maternal healthcare services during pregnancy and reflects basic healthcare engagement.

The second measure, ANC4+, is a binary indicator equal to one if the mother completed at least four antenatal care visits during pregnancy. This variable captures the intensity and continuity of prenatal healthcare utilization and is consistent with the earlier World Health Organization maternal care guidelines, which recommended a minimum of four antenatal visits during pregnancy (WHO, 2016a). Although the WHO later revised its recommendation to eight contacts, the DHS continues to measure antenatal care utilization using the four-visit threshold, allowing for consistent comparison across survey waves and countries.

3.3.3 Infant mortality

Infant mortality is measured as a binary indicator equal to one if a child died before reaching one year of age, and zero otherwise. This outcome is included to explore whether potential changes in maternal healthcare utilization are also reflected in broader child health outcomes. As discussed before in section 2.4 and 2.6, while improved antenatal care and facility-based delivery may contribute to lower infant mortality risk, infant survival depends on a much wider range of factors beyond maternal healthcare-seeking behavior alone, including healthcare quality, disease exposure, nutrition, sanitation and postnatal care. Infant mortality is therefore treated as a secondary and more exploratory outcome within the analysis.

3.4 Main explanatory variables

3.4.1 Internet diffusion

The main explanatory variable is internet users, measured as the percentage of individuals using the internet in a given country-year (World Bank, 2026a). This variable captures the diffusion of digital connectivity over time and serves as a proxy for changes in the broader digital information environment, including access to communication, information and online services. The limitation of this country-year variable is discussed in section 3.1.

3.4.2 Cable treatment

To capture major infrastructure shocks in digital connectivity, a binary treatment indicator (*treat*) is constructed, taking the value one in years following submarine cable arrival in a given country (Hjort & Poulson, 2019b). More information on this variable can be found in section 3.1.

This variable is used in difference-in-differences and event-study analyses to examine whether maternal healthcare outcomes change following major internet infrastructure expansion.

3.5 Heterogeneity variable urban residence

To examine geographic heterogeneity in the relationship between digital connectivity and maternal healthcare utilization, the analysis uses the DHS urban-rural residence indicator (*urban*), coded as one for women living in urban areas and zero for those living in rural areas.

Urban-rural residence is included for both empirical and theoretical reasons discussed in section 2.5. First, access to healthcare services is often unequally distributed across geographic populations, with urban households generally facing shorter travel distances, better transportation infrastructure and greater availability of healthcare facilities. Second, the expansion of digital infrastructure and internet adoption has historically been concentrated in urban areas, where network deployment is less costly and population density is higher.

At the same time, women in rural areas may face greater informational constraints and fewer alternative sources of health-related information. As a result, the marginal effects of internet access

may differ across geographic contexts, potentially generating stronger behavioral responses where baseline access to information is lower. To examine this possibility, urban residence is interacted with both internet diffusion and submarine cable treatment variables in the empirical analysis.

3.6 Control variables

To reduce potential omitted variable bias, the empirical analysis includes a set of individual- and country-level control variables that are theoretically linked to both maternal healthcare utilization and digital adoption. The individual controls are collected alongside the maternal healthcare and infant mortality variables from the DHS.

Maternal age at birth is included to account for life-cycle differences in pregnancy risk, healthcare knowledge and care-seeking behavior. Previous research shows that maternal age influences both perceived need for healthcare and utilization of maternal services, as older women may possess greater experience, autonomy and familiarity with healthcare systems, while very young mothers often face greater informational and socioeconomic barriers to care (Andersen, 1995; Gabrysch & Campbell, 2009). Maternal age is also associated with differences in pregnancy risk and obstetric complications, which may further affect healthcare-seeking behavior and the likelihood of utilizing antenatal and delivery care services.

Birth order is included to capture parity effects. Women with previous childbirth experience may differ in their perceived need for professional care, familiarity with healthcare systems and healthcare utilization decisions compared to first-time mothers. Previous literature suggests that women with higher-order births are often less likely to utilize formal maternal healthcare services, potentially because prior pregnancy experience reduces perceived need for professional care (Gabrysch & Campbell, 2009).

Maternal education is measured using completed years of schooling. As discussed in the literature review, education represents an important predisposing factor within Andersen's Behavioral Model (1995), influencing health literacy, access to information and the ability to navigate healthcare systems. More educated women are consistently found to have higher utilization of maternal healthcare services (Gabrysch & Campbell, 2009).

Completed years of education are used rather than categorical education levels in order to capture variation in educational attainment more continuously and precisely across individuals and countries. This specification additionally allows for a more parsimonious empirical model while preserving greater variation in maternal educational attainment.

At the macroeconomic level, *GDP per capita* (World Bank, 2026b) is included to control for broader economic development, which may simultaneously affect both digital infrastructure expansion and healthcare access. While country fixed effects absorb time-invariant differences in development levels across countries, GDP per capita captures broader economic changes occurring during the study period that could affect both internet diffusion and maternal healthcare utilization.

In robustness specifications, country-level *health expenditure per capita* (World Bank, 2025a) and *urban population share (%)* (World Bank, 2026c) are considered to account for cross-country differences in healthcare investment, service availability and population concentration.

Where data availability permits, additional household-level controls are explored in section 6, including the DHS *wealth index*, *electricity access*, *media exposure* and ownership or use of communication technologies such as *mobile phones* and *internet usage*. These variables may capture household socioeconomic resources, access to information and technological readiness. However, because some of these variables are only available in later survey rounds, and may themselves be influenced by expanding digital infrastructure, they are included selectively in robustness analyses rather than the main specification.

Finally, all regressions include country fixed effects and birth-year fixed effects to account for time-invariant cross-country differences and common temporal shocks affecting all countries.

3.7 Descriptive patterns

Table 1 presents summary statistics for the main variables used in the analysis. The final birth-level dataset includes 1,069,414 observations for infant health outcomes and internet diffusion measures, while the effective sample size is smaller for maternal healthcare outcomes due to differences in DHS questionnaire coverage across survey rounds. Facility delivery is observed for 391,474 births, while antenatal care outcomes are available for 268,879 births.

In the DHS, antenatal care information is not observed for all pregnancies in the same way as basic birth-history information. Instead, these questions are generally collected for live births within selected birth histories and survey modules. This means that pregnancies ending in adverse outcomes, such as stillbirths or other non-live birth outcomes, may be less consistently represented in the antenatal care sample. If women experiencing these adverse outcomes also differ systematically in healthcare access, socioeconomic status or exposure to information, the estimated antenatal care relationships may be affected by sample selection or survival bias. The antenatal care estimates should therefore be interpreted with some caution, as the observed DHS sample may not fully capture all pregnancies equally across maternal health outcomes.

The descriptive statistics already show substantial differences in maternal healthcare utilization between rural and urban women. On average, 56.5 percent of births in the sample took place in a health facility. However, this share is considerably lower among rural women, at 46.7 percent, compared with 78.4 percent among urban women. Similar differences are visible for antenatal care. While 86.3 percent of women received at least one antenatal care visit, the share is 82.7 percent among rural women and 94.1 percent among urban women. For ANC4+, the difference is even larger. 51.6 percent of rural women completed at least four antenatal visits, compared with 70.9 percent of urban women. These patterns confirm the importance of examining urban-rural heterogeneity in maternal healthcare utilization.

Infant mortality is observed for the full analytical sample and averages 6.5 percent. The rate is higher among rural births, at 7.0 percent, compared with 5.3 percent among urban births. This difference is consistent with broader inequalities in access to healthcare, infrastructure and socioeconomic resources across geographic populations.

Internet diffusion varies substantially across the sample period. The average share of individuals using the internet is 6.9 percent, but this masks strong differences before and after submarine cable connectivity. In country-years before cable arrival, average internet use is 1.4 percent, compared with 16.8 percent after cable arrival. This supports the use of cable timing as a relevant marker of major changes in the digital environment, while also showing that internet adoption remained far from universal during the period studied.

Likewise, the control variables reflect the broader socioeconomic context in which maternal healthcare decisions are made. The average mother in the sample is approximately 32 years old at the time of birth, and the average child is the mother's 3.6th birth, indicating that many observations involve women with prior childbirth experience. Mean educational attainment is relatively low, at around four years of schooling, which is consistent with the theoretical expectation that informational and knowledge-related barriers to healthcare utilization may remain substantial across parts of the sample. Household wealth also remains moderate on average, with a mean wealth index of 2.7 on a five-point scale, reflecting the resource constraints that may shape access to formal maternal healthcare services. At the country-year level, GDP per capita averages approximately 1,098 USD, while the average urbanization rate is 37.9 percent, further illustrating the predominantly low-income and partly rural context of the sample countries. Overall, the descriptive statistics indicate substantial variation in maternal healthcare utilization, internet diffusion and socioeconomic conditions across the sample, providing a relevant basis for examining how digital connectivity relates to maternal healthcare behavior across different development settings.

Table 1: Summary statistics

Variables	Observations	Mean	Std. Dev.	Min.	Max.
Facility delivery	391 474	.565	.496	0	1
<i>Rural</i>	270 952	.467	.499	0	1
<i>Urban</i>	120 522	.784	.411	0	1
Any ANC	268 879	.863	.343	0	1
<i>Rural</i>	182 841	.827	.378	0	1
<i>Urban</i>	86 038	.941	.235	0	1
ANC4+	268 879	.578	.494	0	1
<i>Rural</i>	182 841	.516	.500	0	1
<i>Urban</i>	86 038	.709	.454	0	1
Infant death	1 069 414	.065	.247	0	1
<i>Rural</i>	721 598	.070	.255	0	1
<i>Urban</i>	314 864	.053	.224	0	1
Internet users	1 069 414	6.912	10.299	0	69.913
<i>Cable = 0</i>	687 633	1.426	2.400	0	12
<i>Cable = 1</i>	381 781	16.793	11.616	1.68	69.913
Treat	1 069 414	.357	.479	0	1
Urban	1 036 462	.304	.460	0	1

Cable year	1 069 414	2009.931	.853	2009	2012
Observation level controls					
Maternal age	1 069 414	31.878	7.120	15	49
Birth order	1 069 414	3.649	2.426	1	21
Education in years	1 068 990	4.040	4.491	0	26
Media exposure	790 976	.646	.478	0	1
Birth year	1 069 575	2004.424	10.449	1976	2024
Electricity	1 010 723	.300	.458	0	1
Mobile phone	313 031	.573	.495	0	1
Internet use	308 019	.160	.366	0	1
Wealth	840 931	2.695	1.385	1	5
Country level controls					
GDP per capita	1 064 498	1098.337	977.891	96.319	8646.056
Health expenditure per capita	752 672	56.453	74.467	4.176	686.872
Urban rate (%)	1 069 575	37.850	11.274	10.643	63.692

4. Methodology

4.1 Empirical strategy

The baseline empirical strategy estimates the association between internet diffusion in a given country and birth year and individual-level maternal and infant health outcomes. The main specification is:

$$\text{Equation 1: } Y_{ict} = \beta \text{Internet}_{ct} + \gamma X_{ict} + \delta Z_{ct} + \mu_c + \lambda_t + \epsilon_{ict}$$

Where Y_{ict} denotes the outcome for individual birth i in country c and birth year t . The outcomes include facility delivery, antenatal care utilization and infant mortality. Internet_{ct} measures the percentage of individuals using the internet in country c and year t . X_{ict} includes the individual-level controls urban residence, maternal age at birth, birth order and maternal years of education. Z_{ct} includes the country-year control GDP per capita. Country fixed effects μ_c control for time-invariant differences across countries, while birth-year fixed effects λ_t absorb common shocks and secular trends affecting all countries.

This fixed-effects approach is appropriate as the analysis uses repeated birth cohorts across multiple countries and years. Country fixed effects account for persistent cross-country differences in healthcare systems, geography, institutions and baseline development. Birth-year fixed effects control for region-wide time trends, such as general improvements in maternal health, economic development or global changes in internet adoption. The coefficient β is therefore identified from within-country changes in internet diffusion over time, net of common year trends.

Standard errors are clustered at the country level to account for serial correlation and within-country dependence in the error term. As the analysis includes only twelve countries, the number of clusters is limited. This means that statistical inference should be interpreted cautiously, and emphasis is placed not only on p-values but also on the size, direction and consistency of coefficients across specifications.

4.2 Main outcomes

The main maternal healthcare outcome *facility delivery* is central to the analysis because it captures actual use of formal maternal healthcare services at childbirth. Antenatal care outcomes *Any ANC* and *ANC4+* capture both initial contact with formal healthcare services and more continuous engagement during pregnancy. Finally, *infant mortality* is included to examine whether changes in maternal healthcare behavior are associated with broader child health outcomes. However, because this relationship is indirect and influenced by a wide range of factors beyond maternal care-seeking alone, infant mortality is treated as a secondary outcome throughout the analysis.

4.3 Urban-rural heterogeneity

A central part of the methodology is to examine whether the association between internet diffusion and maternal healthcare utilization differs between urban and rural women. This follows from the theoretical framework, which suggests that internet access may reduce informational barriers, but that the marginal value of additional information may differ depending on baseline access to healthcare, media and other information channels.

This specification is especially important as finer geographic measures of exposure, such as distance to cable landing stations or regional backbone infrastructure, are not available in the constructed dataset. The urban-rural interaction therefore provides a theoretically grounded way to introduce within-country heterogeneity in exposure to digital information environments.

To test this, the baseline specification is extended by interacting internet diffusion with the DHS urban residence indicator:

Equation 2:

$$Y_{ict} = \beta_1 Internet_{ct} + \beta_2 Urban_{ict} + \beta_3 (Internet_{ct} \times Urban_{ict}) + \gamma X_{ict} + \delta Z_{ct} + \mu_c + \lambda_t + \epsilon_{ict}$$

Here, β_1 captures the association between internet diffusion and the outcome among rural women, who serve as the reference group. β_3 captures how this association differs for urban women. The total association for urban women is therefore obtained by combining β_1 and β_3 after estimation, which is calculated using post-estimation linear combinations.

Including the main effect of urban residence is essential because urban and rural women differ systematically in baseline healthcare access, infrastructure and socioeconomic conditions. Controlling for these average differences ensures that the interaction term captures differences in the association between internet diffusion and maternal healthcare utilization, rather than pre-existing differences between geographic populations.

4.4 Submarine cable treatment specifications

In addition to using country-year internet penetration, the analysis also considers the arrival of submarine fiber-optic cables as a proxy for major digital infrastructure expansion. This approach is motivated by Hjort and Poulsen (2019a), who show that submarine cable arrival increased internet speeds and usage in connected African regions.

Equation 3:
$$Y_{ict} = \beta Treat_{ct} + \gamma X_{ict} + \delta Z_{ct} + \mu_c + \lambda_t + \epsilon_{ict}$$

This model examines whether maternal health outcomes changed after major improvements in international digital connectivity. However, the cable treatment variable is not used as the main identification strategy in this thesis. The reason is that the initial cohort-based difference-in-differences and event-study analyses produced mixed and inconsistent results across treatment cohorts and outcomes. In addition, some evidence of differential pre-treatment trends was observed, particularly for the 2009 cohort, which weakens the plausibility of a strict parallel trends assumption. More fundamentally, submarine cable arrival represents a broad infrastructure shock rather than immediate individual internet adoption, implying that improvements in digital access and information diffusion likely occurred gradually over time rather than directly at the moment of cable connection. Additional descriptive analysis from section 3.1 further suggests that while cable arrival coincided with broader increases in internet penetration, much of this expansion also reflects gradual continent-wide growth in digital connectivity over time. While cable arrival clearly corresponds to the broader period of increasing internet diffusion (Cariolle, 2021), the relationship between cable timing and maternal health outcomes is therefore not sufficiently precise to support strong causal claims.

For this reason, cable-based models are used as supporting evidence rather than as the primary empirical strategy. They help examine whether results are consistent with the timing of major internet infrastructure expansion, but they are interpreted cautiously.

4.5 Difference-in-differences cohort checks

As submarine cables arrived in different years across countries, additional cohort-based difference-in-difference robustness checks were conducted by comparing earlier-treated cable cohorts with countries that had not yet received cable connectivity during the same period. Separate treatment indicators were constructed for the 2009 and 2010 cable-arrival cohorts.

For the 2009 specification, countries connected in 2009 were compared to countries connected later, namely in 2010 or 2012. To avoid contamination from already-treated observations, later-treated countries were included only during the years in which they had not yet received cable access themselves. Similarly, the 2010 cohort was compared to the later-treated 2012 cohort, with the 2012 countries serving as the untreated comparison group prior to their own cable arrival. The 2012 cohort does not provide a suitable difference-in-differences design because there are too few later-treated countries available to construct a credible control group.

$$\text{Equation 4: } Y_{ict} = \beta \text{Did2009}_{ct} + \gamma X_{ict} + \delta Z_{ct} + \mu_c + \lambda_t + \epsilon_{ict}$$

$$\text{Equation 5: } Y_{ict} = \beta \text{Did2010}_{ct} + \gamma X_{ict} + \delta Z_{ct} + \mu_c + \lambda_t + \epsilon_{ict}$$

To assess the validity of the cohort-based difference-in-differences design, pre-treatment trends were examined separately for the 2009 and 2010 cable-arrival cohorts. Relative event time was defined as the difference between the observation year and the country-specific year of cable arrival.

$$\text{Equation 6: } \text{EventTime}_{ct} = \text{BirthYear}_t - \text{CableYear}_c$$

The year prior to cable arrival ($t = -1$) was used as the reference category, and pre-treatment coefficients were plotted to assess whether treated and later-treated countries followed similar trends before treatment. This serves as a visual diagnostic of the parallel trends assumption underlying the DiD specification.

4.7 Lagged internet specifications

The analysis additionally examines lagged measures of internet diffusion. This is motivated by the expectation that changes in maternal healthcare behavior may not occur immediately following increases in internet access. Processes such as information diffusion, changing social norms and adjustments in healthcare decision-making are likely to develop gradually over time.

One- and two-year lagged internet diffusion variables were therefore constructed at the country-year level prior to merging the data into the individual birth-level dataset. Constructing the lags before the merge is important, as generating lags after merging would incorrectly create lags across individual birth observations rather than across country-year internet measures.

$$InternetLag1_{ct} = Internet_{c,t-1}$$

$$InternetLag2_{ct} = Internet_{c,t-2}$$

The lagged specifications test whether maternal healthcare utilization is associated with earlier levels of internet diffusion rather than only contemporaneous internet penetration. These models are included as robustness checks to assess the sensitivity of the results to alternative timing assumptions, while the contemporaneous internet diffusion measure remains the primary explanatory variable throughout the analysis.

5. Results

5.1 Baseline regression results

Table 2 presents the baseline regression results examining the association between internet diffusion and maternal and infant health outcomes, controlling for maternal characteristics, country fixed effects and birth-year fixed effects. The results show a positive and statistically significant association between internet diffusion and facility delivery. A one percentage-point increase in internet use is associated with a 0.3 percentage-point increase in the probability of delivering in a health facility, suggesting that digital connectivity may help reduce informational barriers to professional maternal care.

For antenatal care, the estimated coefficients are also positive, although only the association with at least one antenatal visit is weakly statistically significant. No statistically significant relationship is found for infant mortality, which is consistent with the fact that infant survival depends on a broader set of factors beyond maternal care-seeking behavior alone.

Urban residence is positively associated with maternal healthcare utilization and negatively associated with infant mortality across specifications, highlighting persistent geographic inequalities in access to care. The control variables generally display the expected relationships, with higher maternal education associated with increased healthcare utilization and lower infant mortality, while higher birth order is associated with lower utilization outcomes.

These baseline estimates provide a useful starting point for identifying broad patterns, but should not be interpreted as fully causal, as internet diffusion may coincide with other country-level developments and country-level exposure may mask important within-country variation in actual access.

Table 2: Baseline associations between internet diffusion and maternal and infant health outcomes

	(1)		(2)		(3)		(4)	
	Facility delivery		Any ANC		ANC4+		Infant death	
Internet users (%)	0.003	**	0.002	*	0.006		0.0001	
	(0.001)		(0.001)		(0.004)		(0.002)	
Urban residence	0.182	***	0.059	**	0.097	***	-0.008	***
	(0.026)		(0.021)		(0.016)		(0.002)	
Maternal age	0.008	***	0.002	**	0.007	***	-0.002	***
	(0.001)		(0.001)		(0.001)		(0.0002)	
Birth order	-0.028	***	-0.006	***	-0.020	***	0.006	***
	(0.003)		(0.002)		(0.003)		(0.001)	
Education in years	0.032	***	0.018	***	0.024	***	-0.001	***
	(0.004)		(0.006)		(0.005)		(0.0001)	
GDP per capita	-0.000		-0.000		-0.000		0.000	
	(0.000)		(0.000)		(0.000)		(0.000)	
Country fixed effects	Yes		Yes		Yes		Yes	
Birth-year fixed effects	Yes		Yes		Yes		Yes	
Observations	391337		268786		268786		1031031	
R ²	0.284		0.167		0.130		0.010	

Notes: Robust standard errors clustered at the country level are reported in parentheses. All specifications include country fixed effects and birth-year fixed effects. The dependent variables are binary indicators. Coefficients are estimated using linear probability models. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.2 Urban-rural heterogeneity

To examine whether the association between internet diffusion and maternal healthcare utilization differs across geographic populations, the baseline specification is extended with an interaction between internet penetration and urban residence. Table 3 presents the results. The coefficient on internet use represents the association for rural women, while the interaction term captures how this association differs for women living in urban areas.

For facility delivery, the results show a positive and statistically significant association between internet diffusion and healthcare utilization among rural women. A one percentage-point increase

in internet penetration is associated with a 0.5 percentage-point increase in the probability of delivering in a health facility. The interaction term is negative and statistically significant, indicating that this association is significantly smaller among urban women. However, combining the main and interaction coefficients ($0.005 - 0.003 = 0.002$) suggests that the overall association for urban women remains positive, although substantially weaker than for rural women. Taken together, the results suggest that the relationship between internet diffusion and facility delivery is strongest among rural women.

This pattern is consistent with the theoretical expectation that rural women face greater informational constraints and more limited access to healthcare and media channels at baseline, potentially increasing the marginal benefits of improved digital connectivity.

For antenatal care outcomes, the coefficients remain positive, but the interaction terms are small and statistically insignificant. This suggests that internet diffusion may support maternal healthcare engagement across both geographic groups, while differences between rural and urban women appear less pronounced for antenatal care utilization than for facility delivery.

For infant mortality, no economically meaningful relationship is observed. Although the interaction coefficient is statistically significant, the estimated magnitude is extremely small and unlikely to reflect substantively important differences in infant mortality risk. This supports the interpretation that internet diffusion is more strongly associated with maternal healthcare behavior than with final child health outcomes, which depend on a broader range of structural, environmental and biological factors.

Overall, the heterogeneity analysis strengthens the central argument of this thesis, that is, digital connectivity appears most strongly associated with maternal healthcare utilization in settings where informational barriers are likely to be greatest, particularly among rural women.

Table 3: Urban-rural heterogeneity in the association between internet diffusion and maternal health outcomes

	(1)		(2)		(3)		(4)	
	Facility delivery		Any ANC		ANC4+		Infant death	
Internet users (%)	0.005	***	0.002	*	0.007	*	0.000	
	(0.001)		(0.001)		(0.003)		(0.000)	
Urban residence	0.210	***	0.062	**	0.104	***	-0.010	***
	(0.038)		(0.022)		(0.018)		(0.002)	
Internet x Urban	-0.003	**	-0.000		-0.001		0.000	***
	(0.001)		(0.001)		(0.001)		(0.000)	
Maternal age	0.008	***	0.002	**	0.007	***	-0.002	***
	(0.001)		(0.001)		(0.001)		(0.000)	
Birth order	-0.028	***	-0.006	***	-0.020	***	0.006	***
	(0.003)		(0.002)		(0.003)		(0.001)	
Education in years	0.033	***	0.019	***	0.024	***	-0.001	***
	(0.004)		(0.006)		(0.005)		(0.000)	
GDP per capita	-0.000		-0.000		-0.000		0.000	*
	(0.000)		(0.000)		(0.000)		(0.000)	
Country fixed effects	Yes		Yes		Yes		Yes	
Birth-year fixed effects	Yes		Yes		Yes		Yes	
Observations	391 337		268 786		268 786		1031031	
R ²	0.285		0.167		0.130		0.010	

Notes: Linear probability models estimated with standard errors clustered at the country level in parentheses. All specifications include country fixed effects and birth-year fixed effects. The coefficient on Internet users (%) represents the association for rural women (reference group). The interaction term indicates how this association differs for urban women. * p < 0.10, ** p < 0.05, *** p < 0.01.

5.3 Cable arrival and urban-rural heterogeneity

Table 4 examines whether the arrival of international submarine cable infrastructure is associated with maternal healthcare utilization and infant health outcomes, and whether these associations differ between rural and urban populations.

Across most outcomes, the coefficient on the post-cable treatment variable is not statistically significant. For facility delivery, the estimated coefficient is negative but close to zero and

statistically insignificant. Similarly, no statistically significant association is observed for any antenatal care utilization. For ANC4+, the post-cable coefficient is negative and weakly statistically significant at the 10 percent level, suggesting that among rural women, births occurring after cable arrival are associated with a lower probability of completing four or more antenatal visits. However, given the absence of similar effects across the other maternal healthcare outcomes, this result should be interpreted cautiously.

The interaction between cable arrival and urban residence reveals some evidence of geographic heterogeneity. For facility delivery, the interaction term is negative and marginally statistically significant at the 10 percent level, suggesting that the post-cable association is weaker in urban areas relative to rural areas. Although the cable-based estimates remain less consistent than the internet diffusion results, this pattern is broadly consistent with the possibility that improvements in digital connectivity may have relatively larger associations in rural settings, where baseline informational constraints are greater.

For both antenatal care outcomes, the interaction terms are statistically insignificant, suggesting that the association between cable arrival and antenatal care utilization does not differ substantially between rural and urban populations.

For infant mortality, the interaction term is positive and statistically significant, implying that the estimated post-cable association is more positive among urban women relative to rural women. However, the estimated magnitude remains small in absolute terms, limiting its substantive interpretation. Moreover, given that infant mortality is shaped by a broad range of healthcare, environmental and socioeconomic factors beyond maternal healthcare-seeking behavior alone, this result should not be interpreted as evidence that cable infrastructure directly worsened child health outcomes. Instead, it more likely reflects concurrent changes occurring during the period of digital expansion that are not fully captured by the cable treatment indicator.

Overall, the cable-treatment results remain less consistent and less precisely estimated than the main internet diffusion specifications. While some evidence of urban-rural heterogeneity emerges, particularly for facility delivery, the findings reinforce the broader conclusion that submarine cable arrival alone does not provide a sufficiently precise measure of digital exposure to support strong causal interpretation.

Table 4: Cable treatment and urban-rural heterogeneity

	(1)		(2)		(3)		(4)	
	Facility delivery		Any ANC		ANC4+		Infant death	
Post-cable period	-0.013		-0.011		-0.074	*	0.001	
	(0.016)		(0.015)		(0.036)		(0.004)	
Urban residence	0.208	***	0.067	**	0.100	***	-0.012	***
	(0.037)		(0.025)		(0.022)		(0.002)	
Post-cable x Urban	-0.058	*	-0.017		-0.005		0.010	***
	(0.029)		(0.016)		(0.019)		(0.002)	
Maternal age	0.008	***	0.002	**	0.007	***	-0.002	***
	(0.001)		(0.001)		(0.001)		(0.000)	
Birth order	-0.028	***	-0.006	***	-0.020	***	0.006	***
	(0.003)		(0.002)		(0.003)		(0.001)	
Education in years	0.033	***	0.019	***	0.024	***	-0.001	***
	(0.004)		(0.006)		(0.005)		(0.000)	
GDP per capita	0.000		-0.000		-0.000		0.000	**
	(0.000)		(0.000)		(0.000)		(0.000)	
Country fixed effects	Yes		Yes		Yes		Yes	
Birth-year fixed effects	Yes		Yes		Yes		Yes	
Observations	391337		268786		268786		1031031	
R ²	0.283		0.166		0.127		0.010	

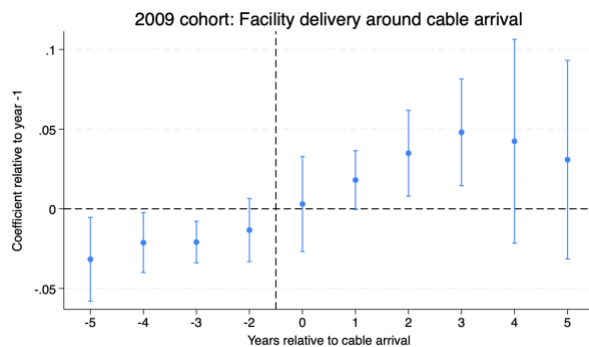
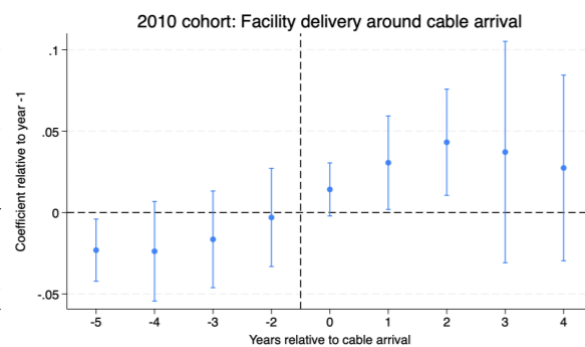
Notes: Linear probability models estimated with standard errors clustered at the country level in parentheses. All specifications include country fixed effects and birth-year fixed effects. Rural women are the reference group. The coefficient on Post-cable period represents the association for rural women, while the interaction term indicates how this association differs for urban women. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6. Robustness

6.1 Cohort-based difference-in-differences design

As a robustness exercise, cohort-specific difference-in-differences models were estimated using variation in the timing of submarine cable arrival across countries. Countries receiving cable access in 2009 were compared to later-treated countries receiving cable access in 2010 or 2012, while the 2010 cohort was compared to the later-treated 2012 cohort. To avoid treatment contamination, later-treated countries were included only during periods in which they had not yet received cable access themselves. This provides a cleaner comparison between early- and later-treated countries prior to treatment adoption among the comparison cohorts.

To assess the validity of the DiD design, pre-treatment trends were examined graphically for both cohorts. Figures 3 and 4 plot event-time coefficients for facility delivery relative to one year before cable arrival. For the 2009 cohort, the earliest pre-treatment coefficient ($t = -5$) is statistically different from zero, suggesting that treated and comparison countries may already have been following different trends several years prior to cable arrival. This raises concerns regarding the parallel trends assumption for this cohort. For the 2010 cohort, a similar deviation is visible at $t = -5$, although the magnitude is smaller and subsequent pre-treatment coefficients remain closer to zero. In several post-treatment periods, estimated coefficients become somewhat more positive, suggesting that any relationship between digital infrastructure expansion and maternal healthcare behavior may emerge gradually rather than immediately following cable arrival. At the same time, confidence intervals remain relatively wide, reflecting limited statistical precision due to the small number of treated cohorts and country clusters. These graphical diagnostics therefore support interpreting the DiD estimates as robustness evidence rather than as the primary causal identification strategy.

Figure 3: Cable arrival 2009 trends**Figure 4:** Cable arrival 2010 trends

Tables 5 and 6 present the corresponding DiD estimates. For the 2009 cohort, cable arrival is associated with a 3.4 percentage-point increase in facility delivery, which is statistically significant at the one percent level. However, given the evidence of differential pre-treatment trends for this cohort, this estimate should be interpreted cautiously. No statistically significant effects are observed for antenatal care utilization, while a small positive coefficient is estimated for infant mortality. For the 2010 cohort, coefficient estimates remain positive across maternal healthcare outcomes, but none are statistically significant.

Overall, the cohort-specific DiD estimates provide only limited and mixed support for an effect of submarine cable arrival on maternal healthcare utilization. While the positive facility delivery effect in the 2009 cohort broadly aligns with the main findings, the presence of pre-treatment differences and the lack of consistent effects across cohorts suggest that cable arrival alone does not provide a sufficiently clean source of identification in this setting. These findings reinforce the broader results of this study, which indicate that actual internet diffusion, rather than infrastructure timing alone, appears to be a more informative measure of digital exposure.

Table 5: Cohort 2009 difference-in-differences estimates by cable arrival year

	(1)		(2)		(3)		(4)
	Facility delivery		Any ANC		ANC4+		Infant death
Cable arrival effect	0.034	***	0.002		0.003		0.006 *
(2009 cohort)	(0.010)		(0.009)		(0.019)		(0.003)

Maternal age	0.007 (0.001)	***	0.002 (0.001)		0.007 (0.001)	***	-0.001 (0.000)	***
Birth order	-0.031 (0.005)	***	-0.006 (0.002)	**	-0.022 (0.003)	***	0.005 (0.001)	***
Urban residence	0.178 (0.025)	***	0.042 (0.022)	*	0.096 (0.020)	***	-0.003 (0.003)	
Education in years	0.034 (0.004)	***	0.020 (0.007)	**	0.026 (0.005)	***	-0.001 (0.000)	**
GDP per capita	-0.000 (0.000)		0.000 (0.000)		0.000 (0.000)	*	-0.000 (0.000)	
Country fixed effects	Yes		Yes		Yes		Yes	
Birth-year fixed effects	Yes		Yes		Yes		Yes	
Observations	120514		70822		70822		261788	
R ²	0.300		0.224		0.119		0.006	

Notes: Linear probability models with standard errors clustered at the country level. All models include country and birth-year fixed effects. Later-treated cohorts are used as controls only prior to their own cable arrival. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 6: Cohort 2010 difference-in-differences estimates by cable arrival year

	(1)		(2)		(3)		(4)
	Facility delivery		Any ANC		ANC4+		Infant death
Cable arrival effect (2010 cohort)	0.007 (0.006)		0.029 (0.021)		0.007 (0.013)		0.005 (0.005)
Maternal age	0.009 (0.002)	***	0.004 (0.001)	**	0.008 (0.001)	***	-0.001 (0.000)
Birth order	-0.030 (0.004)	***	-0.011 (0.002)	***	-0.024 (0.004)	***	0.006 (0.001)
Urban residence	0.158 (0.030)	***	0.066 (0.035)		0.115 (0.025)	***	-0.007 (0.002)
Education in years	0.034 (0.005)	***	0.025 (0.007)	**	0.029 (0.006)	***	-0.001 (0.000)
GDP per capita	0.000 (0.000)		0.000 (0.000)	**	0.000 (0.000)	**	-0.000 (0.000)
Country fixed effects	Yes		Yes		Yes		Yes

Birth-year fixed effects	Yes	Yes	Yes	Yes
Observations	124050	70718	70718	271194
R ²	0.340	0.236	0.169	0.006

Notes: Linear probability models with standard errors clustered at the country level. All models include country and birth-year fixed effects. Later-treated cohorts are used as controls only prior to their own cable arrival. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.2 Lagged heterogeneity models

As an additional robustness check, the baseline and urban-rural heterogeneity models are re-estimated using one-year and two-year lags of internet diffusion. This accounts for the possibility that changes in digital connectivity may influence maternal healthcare behavior with a delay rather than contemporaneously. The results are broadly consistent with the main findings. In the baseline specifications, lagged internet use remains positively associated with facility delivery and antenatal care utilization, while no meaningful association is found for infant mortality. The complete results can be found in appendix D table 1 to 4.

The lagged heterogeneity specifications provide an important robustness check for the central argument. For facility delivery, the coefficient on lagged internet use remains positive and statistically significant for rural women in both the one-year and two-year lag models. The interaction between lagged internet use and urban residence remains negative, indicating that the association is smaller among urban women. This pattern is consistent with the main results and supports the interpretation that internet diffusion is most strongly associated with facility delivery among rural women.

For antenatal care outcomes, lagged internet diffusion is generally positively associated with utilization, although the evidence is weaker and less consistent across specifications. The interaction terms are small and statistically insignificant, suggesting limited evidence of urban-rural heterogeneity for antenatal care. For infant mortality, the estimated coefficients are close to zero and are not interpreted as substantively meaningful.

Overall, the lagged specifications strengthen the robustness of the main findings by showing that the positive association between internet diffusion and facility delivery, particularly among rural women, is not sensitive to alternative timing assumptions regarding digital exposure.

Table 7: Lagged internet diffusion and urban-rural heterogeneity in facility delivery

	(1)	(2)
	Facility delivery	Facility delivery

1-Year lagged internet users	0.005 (0.001)	***	
2-Year lagged internet users			0.005 (0.002)
Urban residence	0.208 (0.037)	***	0.207 (0.038)
1-Year lagged internet users x Urban	-0.003 (0.001)	**	
2-Year lagged internet users x Urban			-0.004 (0.002)
Country fixed effects	Yes		Yes
Birthyear fixed effects	Yes		Yes
Number of observations	391337		391337
R ²	0.285		0.284

Notes: Linear probability models estimated with standard errors clustered at the country level in parentheses. All specifications include controls, country fixed effects and birth-year fixed effects. Rural women are the reference group. * p < 0.10, ** p < 0.05, *** p < 0.01.

6.3 Robustness to household wealth measure

Household wealth is an important factor influencing maternal healthcare decisions and may additionally be correlated with internet access. As an additional robustness check, the DHS household wealth measure is included in the specification, while GDP per capita is excluded. With the inclusion of country and birth-year fixed effects, GDP per capita contributes relatively little additional identifying variation, as it primarily captures within-country changes in economic development over time. This also explains why the estimated GDP coefficients remain close to zero throughout the main specifications.

The positive association between internet diffusion and facility delivery remains statistically significant after controlling for household wealth, although the coefficient decreases slightly from approximately 0.005 to 0.004. This suggests that the relationship between internet diffusion and facility delivery is not entirely driven by differences in household socioeconomic status.

At the same time, the interaction between internet diffusion and urban residence becomes smaller and loses statistical significance once household wealth is included. Household wealth itself is

strongly and positively associated with facility delivery. This suggests that part of the urban-rural heterogeneity observed in the baseline specification may reflect underlying differences in household economic resources in addition to geographic residence alone.

Excluding GDP per capita from the specification does not materially affect the estimated coefficients, indicating that the main findings are not sensitive to the inclusion of country-level income controls. Household wealth is not included in the baseline specification because its availability is substantially more limited across DHS survey waves, leading to a reduction in sample size and the loss of thirteen birth cohorts. As a result, the wealth-adjusted specification is estimated on a smaller and less comparable sample relative to the main analysis. Nonetheless, the robustness specification retains sufficient pre-treatment observations prior to the rapid expansion of internet access in the late 2000s, allowing for a meaningful assessment of whether the main findings are driven by household socioeconomic differences.

The inclusion of household wealth increases the explanatory power of the model, with the R^2 rising from 0.285 in the baseline specification to 0.331 in the wealth-adjusted model. This suggests that household socioeconomic conditions explain an important share of the variation in facility delivery decisions. At the same time, the increase in explanatory power should be interpreted cautiously, as the wealth specification is estimated on a smaller and somewhat different sample due to data limitations across DHS waves.

Table 8: Robustness to household wealth controls: internet diffusion, urban-rural heterogeneity and facility delivery

	(1)		(2)	
	Facility delivery		Facility delivery	
Internet users (%)	0.005	***	0.004	***
	(0.001)		(0.001)	
Urban residence	0.210	***	0.093	**
	(0.038)		(0.033)	
Internet x Urban	-0.003	**	-0.002	
	(0.001)		(0.001)	
Maternal age	0.008	***	0.006	***

	(0.001)		(0.001)	
Birth order	-0.028	***	-0.024	***
	(0.003)		(0.003)	
Education in years	0.033	***	0.023	***
	(0.004)		(0.004)	
Household wealth			0.079	***
			(0.005)	
GDP per capita	-0.000			
	(0.000)			
Country fixed effects	Yes		Yes	
Birthyear fixed effects	Yes		Yes	
Observations	391337		322201	
Birth years in sample	1985-2023		1998-2023	
R ²	0.285		0.331	

Notes: Linear probability models estimated with standard errors clustered at the country level in parentheses. All specifications include maternal age, birth order, maternal education, country fixed effects, and birth-year fixed effects. Rural women are the reference group in the interaction specification. Column (1) reports the baseline specification including GDP per capita. Column (2) controls for household wealth. Household wealth is measured using the DHS household wealth index. The wealth specification is estimated on a smaller sample due to data availability across DHS survey waves, reducing birth-year coverage from 1985–2023 to 1998–2023. * p < 0.10, ** p < 0.05, *** p < 0.01.

6.4 Robustness to alternative control specifications

To assess whether the main findings are sensitive to other omitted socioeconomic or infrastructure-related factors, The facility delivery specification is re-estimated with a range of additional and/or alternative controls. The full results are reported in appendix Table D5, which includes the model with household wealth again. Across all specifications, the coefficient on internet diffusion remains positive, statistically significant and stable in magnitude, with point estimates between 0.003 and 0.005. This pattern indicates that the core association between internet diffusion and facility delivery is robust to the inclusion of richer household- and country-level controls.

Including household wealth reduces the magnitude and statistical significance of the urban interaction term, suggesting that part of the baseline urban–rural heterogeneity in the effect of

internet diffusion operates through differences in household socioeconomic resources. This consideration is further discussed in section 7.2.

Additional controls for health expenditure, national urbanization, media exposure, electricity access, mobile phone ownership and individual internet use do not materially alter the estimated internet coefficient. Although some of these variables are themselves strongly associated with facility delivery, they are not included in the baseline specification because their availability is limited to later DHS survey waves, substantially reducing sample size and shortening pre-treatment coverage. Preserving a longer birth-cohort window is important for the identification strategy of this study, particularly given the focus on changes surrounding the expansion of internet infrastructure in the late 2000s.

Overall, the results suggest that the positive association between internet diffusion and maternal healthcare utilization is not driven solely by alternative socioeconomic or infrastructure-related channels.

7. Discussion

7.1 Internet diffusion as an enabling resource for maternal healthcare utilization

The findings of this thesis suggest that internet diffusion is positively associated with maternal healthcare utilization in Sub-Saharan Africa, particularly with facility-based delivery. This supports the central theoretical argument that digital connectivity may function as an enabling resource in maternal healthcare decision-making. Within Andersen's Behavioral Model of Health Services Use (1995), enabling factors determine whether individuals are able to translate healthcare needs into actual service use. The results of this study suggest that internet diffusion may be understood as part of this enabling environment. It does not provide healthcare directly, but may reduce informational barriers that shape whether women recognize risks, evaluate care options and engage with formal maternal health services.

This interpretation is consistent with the broader literature on information frictions and development. Studies such as Jensen (2007) and Hjort and Poulsen (2019a) show that digital technologies can reduce information asymmetries and alter behavior in economic domains. The findings of this thesis suggest that similar mechanisms may also be relevant for maternal healthcare decisions. Pregnant women may benefit from improved access to information about pregnancy risks, the benefits of skilled birth attendance, the availability of nearby facilities or the experiences of other women. In this sense, the study extends existing ICT and development literature beyond labor markets, productivity and market efficiency, showing that broader digital diffusion may also be associated with health-related behavior.

The stronger and more consistent association for facility delivery compared with antenatal care is particularly important. Facility delivery is a concrete and consequential decision made at the point of childbirth. It often requires prior planning, information about available services, trust in formal healthcare providers and the ability to mobilize household resources. Internet diffusion may therefore be more clearly reflected in this outcome than in antenatal care, which depends on repeated interaction with the healthcare system over the course of pregnancy. The weaker and less consistent antenatal care results suggest that information access alone may be insufficient to change more continuous patterns of healthcare utilization. While digital connectivity may help

women recognize the value of formal care, sustained antenatal care use may depend more strongly on service availability, affordability, provider quality and repeated access.

7.2 Urban-rural differences and the unequal value of information

One of the central findings of this thesis is that the positive association between internet diffusion and facility delivery is strongest among rural women. This result is consistent with the theoretical expectation that the value of digital information depends on the context in which it is received. Rural women often face greater physical distance to healthcare facilities, fewer formal information channels, lower household resources and weaker exposure to health-related communication. In such settings, the marginal value of improved access to information may be greater than in urban areas, where women are more likely to already have access to clinics, media, education and dense social networks.

This finding supports the argument that digital connectivity may matter most where baseline informational constraints are strongest. It also nuances the concern that digital infrastructure primarily benefits already advantaged urban populations. While internet infrastructure has historically expanded first in urban and economically connected areas, the results suggest that broader internet diffusion may still be associated with relatively stronger behavioral changes among rural women once access begins to spread. In this sense, digital connectivity may have the potential to reduce certain informational disadvantages faced by rural populations.

At the same time, the robustness analysis with household wealth introduces an important qualification. When household wealth is included, the rural internet coefficient remains positive, but the urban-rural interaction becomes smaller and loses statistical significance. This suggests that part of the observed urban-rural difference may reflect household socioeconomic resources rather than geography alone. This finding aligns closely with Andersen's Behavioral Model (1995), in which financial resources are a key enabling factor for healthcare utilization. In the context of maternal health, women from wealthier households may be better able to pay for transport, absorb medical costs or overcome logistical barriers to facility delivery.

The implication is that internet diffusion may interact with existing socioeconomic inequalities. Digital information may help women identify and value formal maternal care, but household

resources still shape whether they are able to act on that information. This is important for interpreting the rural findings. The stronger rural association does not imply that digital connectivity automatically eliminates structural barriers. Rather, it suggests that digital diffusion may be particularly valuable in rural settings, while its effects remain conditioned by broader material constraints.

7.3 Why infrastructure timing alone is not enough

The cable-based results are less consistent than the results using continuous internet diffusion. This is theoretically meaningful rather than merely a methodological complication. Submarine cable arrival captures a major supply-side improvement in international digital infrastructure, but it does not necessarily imply immediate or equal access for households. For digital infrastructure to affect maternal healthcare behavior, cable connectivity must translate into broader availability, affordability, adoption and meaningful use.

This helps explain why the continuous internet diffusion measure produces clearer results than the post-cable treatment indicator. Cable arrival may be an important precondition for improved connectivity, but it is not equivalent to digital diffusion in everyday life. The arrival of submarine infrastructure can reduce bandwidth costs and improve internet capacity, yet households may only experience these changes gradually through lower prices, expanded mobile networks, improved service quality and increased social use of digital tools. This distinction is central for interpreting the role of infrastructure in development. Large infrastructure shocks may create the conditions for change, but behavioral responses depend on whether infrastructure becomes accessible and relevant to people's daily decisions.

The lagged specifications further support this interpretation. The association between internet diffusion and facility delivery remains positive when internet use is lagged by one or two years, particularly among rural women. This suggests that the relevant process is unlikely to be immediate. Instead, the relationship may operate through gradual changes in information access, communication networks, social learning and norms around formal delivery care. Maternal healthcare behavior may therefore respond not simply to the moment infrastructure arrives, but to the broader diffusion process that follows.

7.4 Maternal healthcare behavior versus infant mortality

The absence of a meaningful association between internet diffusion and infant mortality is not unexpected given the conceptual framework of this thesis (section 2.6, figure 1). Internet diffusion is theorized to affect maternal health primarily through information, awareness and care-seeking behavior. These mechanisms are more directly connected to intermediate outcomes such as facility delivery and antenatal care than to final health outcomes such as infant survival.

Infant mortality depends on a much wider set of factors beyond whether a woman seeks care during pregnancy or childbirth. These include the quality of care received, emergency obstetric capacity, neonatal care, nutrition, infectious disease exposure, sanitation, household living conditions and broader health system performance. Even when internet diffusion encourages women to seek facility-based care, this does not automatically translate into lower infant mortality if facilities are under-resourced, care quality is low, or postnatal health risks remain high.

This distinction is important for interpreting the contribution of the thesis. The findings do not suggest that internet diffusion is irrelevant for health outcomes. Rather, they indicate that its most direct association is with maternal healthcare behavior, especially facility delivery. Whether behavioral change leads to measurable improvements in infant survival likely depends on the healthcare system women encounter once they seek care.

8. Limitations and future research

8.1 Limitations

While this study provides new evidence on the relationship between internet diffusion and maternal healthcare utilization in Sub-Saharan Africa, several limitations should be considered when interpreting the results.

First, the main explanatory variable, country-level internet use, captures the share of individuals using the internet within a country in a given year rather than whether women in the DHS sample personally used the internet during pregnancy or childbirth. This was a necessary methodological choice, as individual-level internet variables are only available in more recent DHS rounds and contain substantial missing data, which would have significantly reduced both sample size and pre-treatment coverage. While the use of country-year internet diffusion allows consistent measurement across countries and over longer time horizons, it introduces a mismatch between the level of treatment variation and the level at which healthcare decisions are observed. The estimated coefficients should therefore be interpreted as associations with changes in the broader digital environment rather than with individual internet adoption directly.

Second, the analysis is unable to fully capture within-country variation in digital infrastructure and local information environments. Internet access, healthcare quality and transportation infrastructure often vary substantially across regions within the same country. Ideally, the empirical design would incorporate more geographically precise measures of exposure, such as distance to submarine cable landing stations, terrestrial backbone infrastructure or subnational broadband coverage. Due to limitations in data availability and comparability across countries and survey waves, such measures could not be consistently constructed. Instead, geographic heterogeneity is examined through the urban-rural residence indicator, which provides a theoretically meaningful but relatively broad proxy for local differences in digital access and healthcare environments.

Third, the study faces important identification challenges. Internet diffusion often occurs alongside broader processes of economic and social development, including improvements in education, infrastructure, healthcare systems and household living conditions. Although the models include

country fixed effects, birth-year fixed effects and a range of individual- and macro-level controls, unobserved time-varying factors may still influence both internet expansion and maternal healthcare behavior. The robustness analyses show that the main internet coefficient remains relatively stable across alternative specifications, including controls for household wealth, media exposure, electricity access and mobile phone ownership. However, these specifications cannot fully eliminate concerns about omitted variable bias, and the estimated relationships should therefore be interpreted as conditional associations rather than definitive causal effects.

Relatedly, submarine cable arrival was explored as a potential source of exogenous variation in internet expansion, following the identification strategy of Hjort and Poulsen (2019a). While cable-based treatment and cohort-based difference-in-differences specifications provided useful supporting evidence, the results were not sufficiently consistent to support a stronger causal interpretation. In particular, the infrastructure shock represented by cable arrival may not translate immediately into meaningful household-level internet access, as adoption likely occurs gradually through changes in affordability, network expansion and digital uptake over time. For this reason, submarine cable connectivity is treated as a complementary infrastructure proxy rather than as a formal identification strategy.

A further limitation concerns statistical inference. As the analysis covers twelve countries, standard errors are clustered at the country level to account for serial correlation in country-level internet exposure over time. However, the relatively small number of clusters may reduce the reliability of conventional significance testing. To address this concern, interpretation throughout the study emphasizes not only statistical significance, but also the direction, magnitude and consistency of coefficients across baseline, heterogeneity, lagged and alternative control specifications.

In addition, data availability varies substantially across DHS survey rounds. Key maternal healthcare outcomes and several potentially relevant control variables are not consistently available across all survey years. Variables such as household wealth, mobile phone ownership and individual internet use substantially reduce sample size and shorten birth-year coverage, and are therefore included only in robustness analyses rather than in the baseline specification. While this preserves a longer pre-treatment period around the expansion of digital infrastructure, it also

limits the extent to which specific mechanisms behind the observed relationships can be examined directly.

Finally, the antenatal care measures may be affected by sample selection or survivor bias. Unlike the full birth-history data, antenatal care information is not collected equally for all pregnancy outcomes across DHS survey waves. Pregnancies ending in adverse outcomes may therefore be less consistently represented in the observed antenatal care sample. If women experiencing these outcomes also differ systematically in healthcare access, socioeconomic status or exposure to information, the estimated antenatal care relationships may not fully reflect the broader population of pregnancies. The antenatal care findings should therefore be interpreted with some caution.

Taken together, these limitations suggest that the findings should be interpreted as theoretically grounded and consistent associations between digital diffusion and maternal healthcare behavior, rather than as definitive causal estimates. At the same time, the results provide meaningful evidence that changes in digital connectivity may be linked to maternal healthcare decision-making in Sub-Saharan Africa, highlighting the relevance of digital infrastructure as part of the broader information environment shaping healthcare utilization.

8.2 Future research

Several directions for future research follow from these findings. First, more geographically precise measures of digital exposure could improve identification and help distinguish between national digital diffusion and local infrastructure access. Combining geocoded DHS clusters with spatial data on broadband rollout, mobile network coverage or terrestrial fiber infrastructure may provide stronger evidence on localized treatment effects.

Second, the results suggest that internet diffusion may operate partly through informational and socioeconomic channels, particularly in rural areas and among women facing greater resource constraints. Future research could examine these mechanisms more directly by exploring how digital connectivity interacts with health literacy, household bargaining power, female employment or exposure to online social networks.

Finally, this study primarily examines maternal healthcare utilization as an intermediate behavioral outcome. Future work could explore whether the observed changes in care-seeking behavior translate into longer-term health outcomes, such as neonatal survival, vaccination uptake or child nutritional status, particularly in settings where improvements in healthcare utilization can be matched by sufficient health system quality.

Several directions for future research follow from the findings of this study. First, more geographically precise measures of digital exposure could strengthen identification and improve understanding of how digital infrastructure affects maternal healthcare behavior within countries. While this study relies on country-level internet diffusion and urban-rural heterogeneity, future research could combine geocoded DHS cluster data with spatial information on broadband rollout, mobile network expansion, terrestrial fiber infrastructure or distance to submarine cable landing stations. Such approaches would allow researchers to examine whether localized improvements in digital access generate stronger effects in areas where healthcare infrastructure and information access are initially more limited.

Second, future research could examine the mechanisms through which internet diffusion influences maternal healthcare utilization more directly. The findings of this thesis suggest that informational constraints may play an important role, particularly among rural women. However, the present analysis cannot directly observe how women access, interpret or use digital information in healthcare decision-making. Future studies could therefore explore the role of health literacy, exposure to online health information, social learning, female autonomy or household bargaining power in shaping maternal healthcare behavior in increasingly digital environments. Investigating these mechanisms more directly would help clarify whether internet diffusion primarily affects awareness, perceived healthcare quality, social norms or practical access to services.

Third, future research could further examine the relationship between digital connectivity and longer-term maternal and child health outcomes. While this study finds more consistent associations for maternal healthcare utilization than for infant mortality, changes in care-seeking behavior may still contribute to broader health improvements over time, particularly in settings where healthcare systems possess sufficient quality and capacity to translate increased utilization into effective care. Future work could therefore explore outcomes such as neonatal mortality,

postnatal care, childhood vaccination uptake or nutritional status, while also considering how healthcare quality conditions the effectiveness of increased healthcare utilization.

Finally, as internet access in Sub-Saharan Africa continues to expand rapidly, future research may also examine whether and how the relationship between digital connectivity and maternal healthcare changes over time. As digital technologies become more widespread and integrated into everyday life, the marginal effects of internet diffusion may evolve alongside changes in smartphone adoption, digital literacy, healthcare systems and online health services. This may be particularly relevant in rural areas, where digital expansion could increasingly alter how health information is accessed and shared.

9. Conclusion

This thesis examined whether internet diffusion is associated with maternal healthcare utilization in Sub-Saharan Africa, and whether these associations differ between urban and rural populations. Individual birth histories from the Demographic and Health Surveys were combined with country-level indicators of internet diffusion, submarine cable connectivity and macroeconomic development across twelve Sub-Saharan African countries. In doing so, this study contributes new evidence to the relatively underexplored intersection between digital development and maternal health.

The results show that higher levels of internet diffusion are positively associated with maternal healthcare utilization, particularly facility-based delivery. Some positive associations were also found for antenatal care utilization, although these results were less consistent across specifications. No meaningful relationship was found for infant mortality, suggesting that digital connectivity may be more directly reflected in maternal healthcare behavior than in broader child health outcomes. Overall, these findings provide partial support for the first hypothesis, while no meaningful support is found for the third hypothesis.

A central finding of the study is that the positive association between internet diffusion and facility delivery is strongest among rural women. This suggests that digital connectivity may be particularly relevant in settings where women face greater informational and physical barriers to formal healthcare services, supporting the second hypothesis.

Additional analyses using submarine cable arrival as an infrastructure proxy produced less consistent results across outcomes and treatment cohorts, suggesting that infrastructure timing alone may be a relatively coarse measure of meaningful digital exposure. In contrast, lagged specifications and alternative control models broadly supported the main finding that internet diffusion is positively associated with facility delivery, particularly in rural areas.

Taken together, these findings suggest that digital connectivity may function as an enabling resource in maternal healthcare utilization, while remaining strongly conditioned by existing socioeconomic and geographic inequalities. This may be particularly relevant in resource-constrained settings, where informational barriers to healthcare are often substantial. At the same

time, the results should be interpreted cautiously, as the analysis relies on country-level internet diffusion and cannot fully establish causal relationships. Nevertheless, this study provides new evidence that the expansion of digital connectivity may be associated with improvements in maternal healthcare behavior in Sub-Saharan Africa, highlighting the importance of considering digital infrastructure not only as an economic input, but also as part of the broader information environment shaping health equity and inclusive development.

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Appendices

Appendix A: AI statement

The following AI-based tools were used during the thesis process: OpenAI ChatGPT (<https://chatgpt.com/>); Microsoft Copilot (<https://copilot.microsoft.com/>); and Elicit (<https://elicit.com/>)

Degree and purpose of use

These tools were used in a supportive capacity throughout different stages of the research and writing process.

During the early stages of the thesis, ChatGPT and Microsoft Copilot were used for idea generation, refining the research focus and discussing possible theoretical perspectives and empirical approaches. During the quantitative analysis phase, generative AI tools were used to assist with STATA coding, including checking syntax, troubleshooting code errors and suggesting relevant statistical commands and model specifications.

During the writing process, ChatGPT and Copilot were used to support language improvement, proofreading, grammar and spelling checks, reducing repetition, improving academic phrasing, refining section structure and suggesting alternative titles, headings and subheadings. These tools were also used to provide feedback on the clarity, coherence and overall structure of the sections.

Elicit was used during the literature review phase to identify potentially relevant academic articles and research papers related to digital infrastructure, healthcare utilization and development economics that may not have been identified through my initial database searches using Finn and Web of Science. All suggested literature was independently reviewed and evaluated before inclusion.

All AI-generated outputs and recommendations were critically assessed and edited before use. The interpretation of the literature, the empirical analysis, data cleaning, model selection, results interpretation and all final academic judgments are my own.

Appendix B

Table B1: Sample construction

Country	DHS wave availability	Submarine cable arrival	Pre-cable DHS waves	Post-cable DHS waves	Location (all connected to coast)
Benin	1996 2001 2006 2011–12 2017–18	2010	1996 2001 2006	2011-2012 2017-2018	West
D.R. Congo	2007 2013–14 2023–24	2012	2007	2013-2014 2023-2024	Central (minimal coast)
Ghana	1988 1993 1998 2003 2008 2014 2022	2010	1988 1993 1998 2003 2008	2014 2022	West
Kenya	1989 1993 1998 2003 2008–09 2014 2022	2009	1989 1993 1998 2003 2008-2009	2014 2022	East
Madagascar	1992 1997 2003–04 2008–09 2021	2010	1992 1997 2003-2004 2008-2009	2021	East
Mozambique	1997 2003 2011 2022-23	2009	1997 2003	2011 2022-23	South
Namibia	1992 2000 2006–07 2013	2012	1992 2000 2006-2007	2013	South
Nigeria	1990	2010	1990	2013	West

	2003 2008 2013 2018 2024		2003 2008	2018 2024	
South Africa	1998 2016	2009	1998	2016	South
Tanzania	1991–92 1996 1999 2004–05 2010 2015–16 2022	2009	1991-92 1996 1999 2004-2005	2010 2015-2016 2022	East
Senegal	1986 1992–93 1997 2005 2010–11 2012-13 2017 2023	2010	1986 1992-1993 1997 2005	2010-2011 2012-13 2017 2023	West
Togo	1988 1998 2013–14	2010	1988 1998	2013-2014	West

B2: Reference list of DHS datasets per country

Benin

Institut National de la Statistique et de l'Analyse Economique - INSAE/Benin & ORC

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D.R. Congo

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Ghana

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Appendix C

Table C1: Association between submarine cable arrival and internet diffusion

Variables	(1) Internet users (%)	(2) Internet users (%)
Cable treatment	17.053***	-1.253
	(3.146)	(0.983)
Country fixed effects	Yes	Yes
Birth-year fixed effects	No	Yes
Observations	427	427
Number of countries	12	12
Country fixed effects	Yes	Yes
Birth-year fixed effects	No	Yes
Within R ²	0.500	0.729

Notes: Standard errors clustered at the country level are reported in parentheses. Column (1) reports a country fixed-effects specification examining the association between submarine cable arrival and internet penetration. Column (2) additionally includes birth-year fixed effects to account for common time trends in internet expansion. The dependent variable is the percentage of individuals using the internet in a given country-year. *** p < 0.01.

Table C2: Availability and distribution of individual-level digital access variables

Variable	Observations available	Mean (total)	Rural mean	Urban mean	Earliest birth year	Latest birth year
Internet use	308,019	0.160	0.085	0.308	2006	2023
Mobile phone ownership	313,031	0.573	0.467	0.780	2006	2023

Notes: Internet use and mobile phone ownership are binary indicators measured at the individual level in selected DHS survey waves. Rural and urban means are reported separately to illustrate geographic disparities in digital access. Both variables are only available in relatively recent survey rounds and contain substantial missing observations across countries and years.

Table C3: Temporal coverage and sample sizes by outcome variable

Variable	Observations available	Year min	Year max
Infant death	1069414	1976	2023
Facility delivery	391474	1985	2023
Any ANC	268879	1985	2023
ANC4+	268879	1985	2023

Appendix D

Table D1: 1 year lagged internet diffusion baseline

	(1) Facility delivery		(2) Any ANC		(3) ANC4+		(4) Infant death	
1-Year lagged internet users (%)	0.004 (0.001)	***	0.002 (0.001)	*	0.007 (0.004)	*	0.000 (0.000)	
Urban Residence	0.182 (0.026)	***	0.059 (0.021)	**	0.097 (0.016)	***	-0.008 (0.002)	***
Maternal age	0.008 (0.001)	***	0.002 (0.001)	**	0.007 (0.001)	***	-0.002 (0.000)	***
Birth order	-0.028 (0.003)	***	-0.006 (0.002)	***	-0.020 (0.003)	***	0.005 (0.001)	***
Education in years	0.032 (0.004)	***	0.018 (0.006)	***	0.024 (0.005)	***	-0.001 (0.000)	***
GDP per capita	-0.000 (0.000)		-0.000 (0.000)		-0.000 (0.000)		0.000 (0.000)	**
Country fixed effects	Yes		Yes		Yes		Yes	
Birthyear fixed effects	Yes		Yes		Yes		Yes	
Observations	391337		268786		268786		1016970	
R ²	0.284		0.167		0.131		0.010	

*** p<.01, ** p<.05, * p<.1

Table D2: 2 year lagged internet diffusion baseline

	(1) Facility delivery		(2) Any ANC		(3) ANC4+		(4) Infant death	
2-Year lagged internet users (%)	0.003 (0.002)	*	0.003 (0.001)	*	0.008 (0.004)		0.000 (0.000)	
Urban Residence	0.182 (0.026)	***	0.059 (0.021)	**	0.097 (0.016)	***	-0.008 (0.002)	***
Maternal age	0.007 (0.001)	***	0.002 (0.001)	**	0.007 (0.001)	***	-0.002 (0.000)	***
Birth order	-0.028 (0.003)	***	-0.006 (0.002)	***	-0.020 (0.003)	***	0.005 (0.001)	***
Education in years	0.032 (0.004)	***	0.018 (0.006)	***	0.024 (0.005)	***	-0.001 (0.000)	***
GDP per capita	-0.000 (0.000)		-0.000 (0.000)		-0.000 (0.000)		0.000 (0.000)	**
Country fixed effects	Yes		Yes		Yes		Yes	

Birthyear fixed effects	Yes	Yes	Yes	Yes
Observations	391337	268786	268786	1002704
R ²	0.283	0.167	0.130	0.010

*** p<.01, ** p<.05, * p<.1

Table D3: 1 year lagged internet diffusion and urban-rural heterogeneity

	(1)		(2)		(3)		(4)	
	Facility delivery		Any ANC		ANC4+		Infant death	
1-Year lagged internet users (%)	0.005	***	0.002	*	0.007	*	-0.000	
	(0.001)		(0.001)		(0.004)		(0.000)	
Urban Residence	0.208	***	0.061	**	0.102	***	-0.010	***
	(0.037)		(0.022)		(0.017)		(0.002)	
1-Year lagged internet users x Urban	-0.003	**	-0.000		-0.001		0.000	***
	(0.001)		(0.001)		(0.001)		(0.000)	
Maternal age	0.008	***	0.002	**	0.007	***	-0.002	***
	(0.001)		(0.001)		(0.001)		(0.000)	
Birth order	-0.028	***	-0.006	***	-0.020	***	0.005	***
	(0.003)		(0.002)		(0.003)		(0.001)	
Education in years	0.033	***	0.019	***	0.024	***	-0.001	***
	(0.004)		(0.006)		(0.005)		(0.000)	
GDP per capita	-0.000		-0.000		-0.000		0.000	**
	(0.000)		(0.000)		(0.000)		(0.000)	
Country fixed effects	Yes		Yes		Yes		Yes	
Birthyear fixed effects	Yes		Yes		Yes		Yes	
Observations	391337		268786		268786		1016970	
R ²	0.285		0.167		0.131		0.010	

*** p<.01, ** p<.05, * p<.1

Table D4: 2 year lagged internet diffusion and urban-rural heterogeneity

	(1)		(2)		(3)		(4)	
	Facility delivery		Any ANC		ANC4+		Infant death	
2-Year lagged internet users (%)	0.005	**	0.003	**	0.008	*	-0.000	
	(0.002)		(0.001)		(0.004)		(0.000)	
Urban Residence	0.207	***	0.060	**	0.101	***	-0.010	***
	(0.038)		(0.022)		(0.017)		(0.002)	
2-Year lagged internet users x Urban	-0.004	*	-0.000		-0.001		0.000	**
	(0.002)		(0.001)		(0.001)		(0.000)	
Maternal age	0.008	***	0.002	**	0.007	***	-0.002	***
	(0.001)		(0.001)		(0.001)		(0.000)	
Birth order	-0.028	***	-0.006	***	-0.020	***	0.005	***

	(0.003)		(0.002)		(0.003)		(0.001)	
Education in years	0.033	***	0.019	***	0.024	***	-0.001	***
	(0.004)		(0.006)		(0.005)		(0.000)	
GDP per capita	-0.000		-0.000		-0.000		0.000	**
	(0.000)		(0.000)		(0.000)		(0.000)	
Country fixed effects	Yes		Yes		Yes		Yes	
Birthyear fixed effects	Yes		Yes		Yes		Yes	
Observations	391337		268786		268786		1002704	
R ²	0.284		0.167		0.130		0.010	

*** p<.01, ** p<.05, * p<.1

Table D5: Robustness of internet diffusion and urban-rural heterogeneity to alternative control variables

Facility delivery	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Internet users (%)	0.005 *** (0.001)	0.004 *** (0.001)	0.004 *** (0.001)	0.005 *** (0.001)	0.004 *** (0.001)	0.004 *** (0.001)	0.003 *** (0.001)	0.003 *** (0.001)
Urban residence	0.210 *** (0.038)	0.093 ** (0.033)	0.192 *** (0.038)	0.211 *** (0.038)	0.177 *** (0.037)	0.173 *** (0.030)	0.145 *** (0.042)	0.168 *** (0.043)
Internet x Urban	-0.003 ** (0.001)	-0.002 (0.001)	-0.002 * (0.001)	-0.003 ** (0.001)	-0.002 * (0.001)	-0.003 ** (0.001)	-0.002 (0.001)	-0.002 (0.001)
Maternal age	0.008 *** (0.001)	0.006 *** (0.001)	0.008 *** (0.001)	0.008 *** (0.001)	0.008 *** (0.001)	0.007 *** (0.001)	0.009 *** (0.001)	0.010 *** (0.001)
Birth order	-0.028 *** (0.003)	-0.024 *** (0.003)	-0.030 *** (0.003)	-0.028 *** (0.003)	-0.029 *** (0.003)	-0.025 *** (0.003)	-0.031 *** (0.003)	-0.033 *** (0.003)
Education in years	0.033 *** (0.004)	0.023 *** (0.004)	0.033 *** (0.004)	0.033 *** (0.004)	0.029 *** (0.004)	0.030 *** (0.004)	0.028 *** (0.005)	0.031 *** (0.005)
Household wealth		0.079 *** (0.005)						
GDP per capita	-0.000 (0.000)		0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 ** (0.000)	0.000 ** (0.000)
Health expenditure per capita			-0.000 (0.000)					
National urbanization rate				-0.007 (0.005)				
Media exposure					0.098 *** (0.011)			
Electricity						0.124 *** (0.019)		
Mobile phone ownership							0.105 *** (0.010)	
Individual internet use								0.031 ** (0.011)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	391337	322201	315732	391337	300031	371951	101269	99613
First birth year in sample	1985	1998	2000	1985	1993	1985	2010	2010
R ²	0.285	0.331	0.304	0.285	0.314	0.296	0.350	0.341

Notes: Linear probability models estimated with standard errors clustered at the country level in parentheses. The dependent variable is facility delivery. All specifications include maternal age, birth order, maternal education, country fixed effects, and birth-year fixed effects. Column (1) reports the main specification. Columns (2)–(8) sequentially add alternative household- and country-level controls. Sample size and year coverage varies across specifications due to differences in variable availability across DHS survey waves. Rural women are the reference group in the interaction specification. * p < 0.10, ** p < 0.05, *** p < 0.01.

