The Impact of 3G Network Coverage on Fertility Decisions and Infant Mortality in Nigeria

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Abstract

This study examines the causal relationship between 3G mobile network coverage, fertility decisions, and infant mortality in Nigeria. Using geo-referenced data from Nigerian Demographic and Health Surveys (2013-2018) matched with mobile coverage information, we implement two-way fixed effects for fertility analysis and a sample selection model for infant mortality. Results show that increased 3G coverage significantly reduces birth rates, with effects approximately twice as strong for adolescent women (15-19 years). The spatial gradient of effects—stronger at closer proximity (20km) and diminishing with distance (40km)—supports a causal interpretation. For infant mortality, our selection-corrected models reveal no statistically significant direct relationship between 3G coverage and child survival outcomes after accounting for fertility decisions. These findings indicate that mobile connectivity primarily influences demographic outcomes through fertility decisions rather than through direct effects on child survival, suggesting telecommunications infrastructure investments may yield substantial demographic benefits primarily through reduced fertility rates, particularly among adolescents.

Keywords: Mobile Internet, Infant Mortality, Sample Selection Bias

JEL Codes: I15, O33, J13

Introduction

Despite significant global progress in reducing under-five mortality rates from 93.4 deaths per 1,000 live births in 1990 to 37.7 in 2023 (Hug et al., 2019), Nigeria continues to face substantial challenges in both infant mortality and high fertility rates. Nigeria has the largest population in Sub-Saharan Africa, with around 229 million people as of 2024 (Fund, 2024). With a fertility rate of 5.1% according to World Bank data (Division, 2020), understanding the factors that influence both fertility decisions and child survival is critical for developing effective interventions. The rapid expansion of information and communication technologies (ICTs) across developing countries represents one of the most significant technological transformations of the 21st century. In Sub-Saharan Africa, the proliferation of mobile networks—particularly 3G technology since 2013—has fundamentally altered information accessibility in regions traditionally characterized by infrastructure deficits and resource constraints. This technological diffusion offers a unique opportunity to examine how improved access to information influences critical demographic outcomes, specifically fertility decisions and infant mortality rates, which remain central challenges to human capital development and economic progress in Nigeria, Africa's most populous nation.

Nigeria presents a compelling case study for investigating the relationship between digital connectivity and reproductive health outcomes. Despite modest improvements in recent decades, the country continues to experience high fertility rates and elevated infant mortality, with significant regional disparities reflecting uneven development patterns. These demographic challenges persist despite various policy interventions, suggesting that information barriers and structural constraints may play important roles in limiting progress. The absence of informed reproductive choices has been identified as a key driver of Nigeria's high fertility rates. As noted by Iyanda et al. (2020), many married young women lack correct knowledge of ovulation, leading to unintentional pregnancies. This information gap represents a significant public health challenge that potentially connects to both fertility outcomes and infant mortality.

The expansion of 3G networks potentially addresses several critical information constraints affecting reproductive health decisions. Mobile connectivity can facilitate access to family planning information, overcome geographical barriers to healthcare knowledge in regions with limited physical infrastructure, and enable the dissemination of culturally appropriate reproductive health messaging (Billari et al., 2019, 2020). Furthermore, mobile technology may influence fertility and infant survival through indirect pathways—by expanding economic opportunities for women, altering traditional gender roles, and transforming social norms regarding family size and childcare practices. These factors collectively impact human capital and economic development in Sub-Saharan Africa through population dynamics, workforce participation, and educational attainment (Bloom et al., 2010).

However, establishing causal relationships between mobile network coverage and demographic outcomes presents significant empirical challenges. Network access typically correlates with various socioeconomic factors that independently influence fertility and infant mortality, introducing potential endogeneity concerns. As documented by Guldi and Herbst (2017), areas with robust mobile connectivity often feature higher education levels, greater economic resources, and enhanced healthcare access—factors that shape reproductive decisions independent of information technology effects. Past studies have highlighted the complex and ambiguous implications of expanded mobile broadband internet on fertility outcomes in developing country contexts. Some research suggests increased total fertility rates at the national level (Billari et al., 2019) and higher birth rates of second and subsequent children for higher-educated women (Kalabikhina, 2020). Other studies found that mobile internet access is associated with reduced ideal family size and lower parity (Billari et al., 2020). These contradictory findings may be explained through various mechanisms: internet expansion is associated with increased marriage rates (Bellou, 2015) and better work-life balance (Dettling, 2017).

This research will explore how the expansion of 3G coverage influences both fertility decisions and infant mortality outcomes in Nigeria, accounting for these digital, gender, and regional divides. Our research draws on comprehensive data from the Nigerian Demographic and Health Surveys (NDHS) conducted in 2013 and 2018, a period coinciding with significant 3G network expansion across the country. By linking individual-level fertility and health data with geo-referenced information on mobile coverage from Collins Bartholomew, we construct a unique dataset that enables high-resolution analysis of the relationship between digital connectivity and demographic outcomes.

By employing Demographic and Health Surveys data and two-way fixed effect models, the study aims to identify causal relationships between mobile broadband access, reproductive knowledge, healthcare information, and ultimately, fertility and child survival outcomes. This study advances the literature by implementing a rigorous identification strategy to isolate the causal impact of 3G network expansion on fertility decisions and infant mortality in Nigeria. We use two-way fixed effects to analyze the effect of 3G coverage on female fertility decisions. For infant mortality outcomes, we face a significant selection problem, as we only observe the status of children whose mothers gave birth. Given that we expect mortality to be higher among areas with lower mobile coverage, and for these areas to have higher birth rates, the assumption of missing at random is clearly not appropriate in this case and could potentially bias estimates of the effect of mobile coverage. Therefore, we estimate binary response panel data models with sample selection and self-selection by using methodology proposed by Semykina and Wooldridge (2018). This approach allows us to account for the non-random selection processes that might otherwise confound our estimates of the relationship between 3G coverage and infant survival.

Our analysis reveals that increased 3G mobile network coverage significantly reduces birth rates in Nigeria, with particularly pronounced effects among adolescent women aged 15-19 years, where the impact is approximately twice as strong compared to the general population. The observed spatial gradient of effects—stronger at closer proximity (20km) to coverage areas and diminishing with distance (40km)—strongly supports a causal interpretation of these findings. When examining infant mortality outcomes using selection-corrected models, we found no statistically significant direct relationship between 3G coverage and child survival after accounting for fertility decisions. These results suggest that mobile connectivity primarily influences demographic outcomes through fertility decisions rather than through direct effects on child survival. These findings indicate that telecommunications infrastructure investments may yield substantial demographic benefits primarily through reduced fertility rates, particularly among adolescents, rather than through direct improvements in infant survival outcomes.

This study contributes to multiple strands of literature. First, it enhances our understanding of fertility decision-making in developing countries, building upon research suggesting that reproductive health information can significantly influence childbearing intentions and contraceptive use (Williamson et al. 2014). Second, it expands the growing body of research examining the social and public health implications of mobile technology in developing contexts, complementing studies on political engagement (Guriev et al., 2021; Manacorda and Tesei, 2020) and migration patterns (Adema, Aksoy, and Poutvaara, Adema et al.). Finally, our findings directly inform policy objectives aligned with the United Nations' Sustainable Development Goals, particularly target 3.7, which aims to ensure universal access to sexual and reproductive healthcare services.

Beyond its academic contributions, this research carries significant policy implications for Nigeria and similar developing contexts. Understanding how technological infrastructure affects demographic outcomes can inform integrated approaches to development that leverage digital connectivity to improve population health and economic opportunities simultaneously. As Nigeria and other Sub-Saharan African nations continue to invest in telecommunications infrastructure, evidence on the demographic returns to such investments becomes increasingly valuable for resource allocation and policy design.

Background and Conceptual framework

The Evolution of Mobile Telecommunications in Nigeria

Nigeria's telecommunications landscape has undergone a remarkable transformation since the liberalization of the sector in 2001. From fewer than 500,000 phone lines serving a population of over 120 million in 2000, the country has witnessed explosive growth in mobile telecommunications adoption, reaching approximately 198 million active mobile subscriptions by 2020. This dramatic expansion occurred in distinct technological waves, beginning with basic 2G services focused primarily on voice and SMS in the early 2000s, followed by the gradual introduction of 3G networks starting in urban centers around 2008, and accelerating significantly after 2013.

The 3G technology represents a pivotal advancement beyond basic connectivity, enabling substantially faster data transfer speeds that support internet browsing, video streaming, and application-based services. Unlike its predecessor, 3G facilitates access to rich multimedia content and interactive platforms that can deliver complex health information, including visual demonstrations of childcare practices, reproductive health education, and maternal healthcare guidance. This technological leap has been particularly consequential in Nigeria, where physical infrastructure deficiencies have historically limited the reach of conventional information and healthcare delivery systems.

The pattern of 3G network expansion across Nigeria has not been uniform. Initial deployment prioritized urban centers and economically vibrant regions, gradually extending to semi-urban areas, with rural and remote communities typically experiencing delayed coverage. This staged roll-out creates variation in exposure to 3G services that helps identify the technology's effects, though it also raises concerns about potential selection bias that our methodological approach addresses.

Information Access and Fertility Decisions in Developing Contexts

Fertility decisions in developing countries occur within complex socio-cultural contexts characterized by imperfect information and constrained choice sets. The economic theory of fertility, pioneered by (Becker, 1960) and elaborated by subsequent scholars, conceptualizes fertility as a rational choice influenced by the costs and benefits of childbearing, subject to budget constraints and preference structures. Within this framework, information access plays a crucial role in shaping both the perceived costs/benefits of children and the technical knowledge required to implement fertility preferences.

Information constraints affecting fertility decisions in Nigeria and similar contexts operate through multiple channels. First, limited awareness of contraceptive options restricts the ability to control family size, despite expressed desires for fewer children (Bongaarts, 2014). Second, insufficient knowledge about the health risks of closely spaced pregnancies or early childbearing contributes to suboptimal birth timing decisions. Third, misconceptions about contraception safety and side effects create barriers to adoption even when methods are physically available. Fourth, incomplete understanding of the economic returns to education may lead to underinvestment in child quality relative to quantity.

Mobile connectivity potentially relaxes these information constraints through several mechanisms. Direct access to health information via mobile internet can improve knowledge about reproductive health, contraceptive methods, and child spacing. Mobile financial services may enhance women's economic independence, altering intra-household bargaining dynamics regarding fertility. Social media and digital communication can accelerate the diffusion of new social norms regarding family size and women's roles. Lastly, mobile-based reminder systems and health applications can support the consistent use of contraception and adherence to antenatal care schedules.

Mobile Technology and Infant Mortality: Theoretical Linkages

The potential pathways through which mobile connectivity may influence infant mortality are multifaceted. From a theoretical perspective, we identify four primary mechanisms that connect 3G coverage to child survival outcomes.

First, Enhanced mobile connectivity significantly improves information access and health knowledge for caregivers. With 3G networks, individuals can readily access critical information regarding danger signs during pregnancy, essential newborn care practices, proper infant feeding, and timely recognition of illness symptoms requiring medical attention. This expanded knowledge base can substantially improve preventive behaviors and accelerate care-seeking when needed, ultimately leading to better health outcomes.

Second, Mobile connectivity also facilitates healthcare utilization through multiple channels. It enables appointment scheduling, provides transportation information, supports telemedicine consultations in remote areas, and allows price comparisons across healthcare providers. These improvements may increase the likelihood of skilled birth attendance and timely immunization, both critical determinants of infant survival, particularly in resource-constrained environments where healthcare access has traditionally been limited.

Beyond these consumer-facing benefits, 3G connectivity strengthens healthcare delivery systems through improved inventory management, health worker communication, and digital record-keeping. These enhancements can reduce stock-outs of essential medicines and strengthen referral networks for complicated cases, creating more resilient and responsive healthcare infrastructure that better serves maternal and child health needs. Additionally, as documented by Chiplunkar and Goldberg (2022), mobile connectivity expands economic opportunities, particularly for women. The resulting income effects and female empowerment may translate into improved household nutrition, enhanced healthcare access, and greater maternal autonomy in child health decision-making. This socioeconomic dimension of connectivity creates a complementary pathway through which mobile technology can influence child survival outcomes beyond direct health information effects.

The relationship between mobile connectivity and infant survival is likely moderated by several contextual factors. Network effects may generate increasing returns as adoption reaches critical thresholds within communities. Complementary factors such as literacy levels, electricity access, and baseline healthcare infrastructure may condition the technology's impact. Additionally, heterogeneous effects may exist across socioeconomic strata, with potentially larger benefits accruing to disadvantaged households with more significant initial information constraints.

Conceptual Framework: Integrated Model of Technology, Information, and Health Outcomes

Building upon these theoretical foundations, we develop an integrated conceptual framework that links 3G mobile coverage to fertility and infant mortality outcomes through a cascading sequence of information, behavioral, economic, and health system effects.

In our model, 3G coverage initially expands access to diverse information sources, including formal health websites, peer networks, and multimedia educational content. This enhanced information environment influences women's fertility preferences, contraceptive knowledge, and reproductive autonomy. Simultaneously, it shapes maternal health behaviors through improved awareness of optimal pregnancy care, delivery options, and postnatal practices.

These informational changes trigger behavioral adaptations in both fertility decisions (contraceptive adoption, birth spacing, marriage timing) and maternal-child health practices (antenatal care utilization, skilled birth attendance, breastfeeding, immunization). The model acknowledges bidirectional relationships between fertility and infant mortality, as optimal birth spacing directly influences child survival probabilities, while infant mortality experiences may reciprocally affect subsequent fertility decisions through replacement effects or risk perceptions.

Critically, our framework recognizes that these processes operate within specific socioeconomic, cultural, and infrastructural contexts that may amplify or attenuate the technology's effects. Women's education levels, household economic status, community healthcare infrastructure, and prevailing gender norms all potentially moderate the relationship between improved information access and health outcomes. This contextual embeddedness necessitates empirical approaches that can account for potential endogeneity and selection issues, as we implement in our methodology.

The framework informs our empirical strategy by identifying key mediating variables to explore and potential heterogeneities to test. By examining sequential links in this causal chain—from technology access to information exposure to behavioral change to health outcomes—we can illuminate the mechanisms through which digital connectivity shapes demographic outcomes in developing contexts.

Data

Mobile Broadband Coverage within Cluster

Mobile broadband coverage is precessed by integrating Demographic and Health Survey (DHS) locations with GSM (Global System for Mobile Communications) coverage data in Nigeria. I use 3G coverage data released annually, where each year's release (e.g., 2010) contains operator data collected through the end of the previous year (2009). Using DHS cluster points from the 2013 and 2018 surveys, the methodology creates multiple circular buffer zones at varying distances (0.5 to 100 kilometers) around each survey cluster. These locations are first transformed into the UTM 32 projection system, appropriate for Nigeria's geographic position. For each buffer zone, the code processes mobile coverage data from GSM TIF files, calculating coverage values through a spatial analysis that counts non-

NA cells within each buffer and normalizes these values relative to the maximum count. The analysis generates a comprehensive dataset recording the coverage (GSMCOVER), year (GSMYEAR), generation type (GSMGEN), and buffer distance (BUFFERDIST) for each DHS cluster point.

The maps illustrate the dramatic expansion of 3G mobile network coverage across Nigeria between 2013 and 2018, which provides the key variation for our identification strategy Figures 1 and 2. Each dot represents a survey cluster from the NDHS, with colors indicating the fraction of 3G coverage in the surrounding area (purple: 0.000-0.021, teal: 0.021-0.105, green: 0.105-0.311, and yellow: 0.311-1.000). In 2013, 3G coverage was largely concentrated in urban centers and southern regions, particularly around Lagos, parts of Oyo, and the Niger Delta. Most of northern Nigeria had minimal coverage (purple dots), with the exception of a few isolated pockets around state capitals. Even in southern Nigeria, high-coverage areas (yellow dots with 31.1-100By 2018, there was a substantial expansion of 3G coverage throughout the country. The yellow high-coverage areas expanded significantly across the southwest and south-south regions, creating contiguous zones of high connectivity. Northern Nigeria also experienced considerable improvement, with many areas transitioning from minimal coverage (purple) to low-moderate coverage (teal and green). Notable expansion occurred in parts of Kano, Kaduna, and Katsina states, though the far northeastern regions continued to lag behind. This pattern of expansion was not uniform across all regions, creating valuable variation for our empirical analysis. The heterogeneous rollout of 3G networks—with some areas gaining access early, others later, and some remaining with limited coverage—allows us to examine how differential exposure to mobile internet affects fertility decisions and infant mortality outcomes while controlling for time-invariant regional characteristics through our two-way fixed effects models.

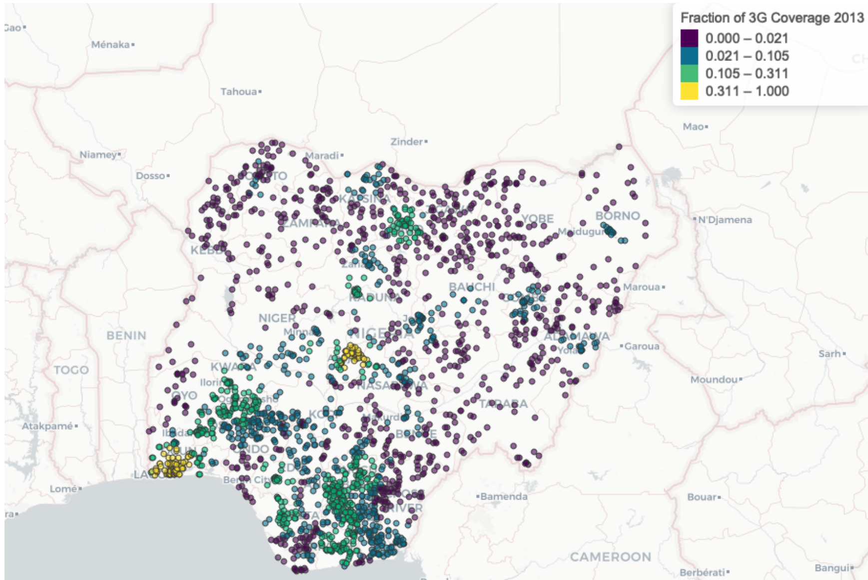

Figure 1: Mobile Coverage in 2013

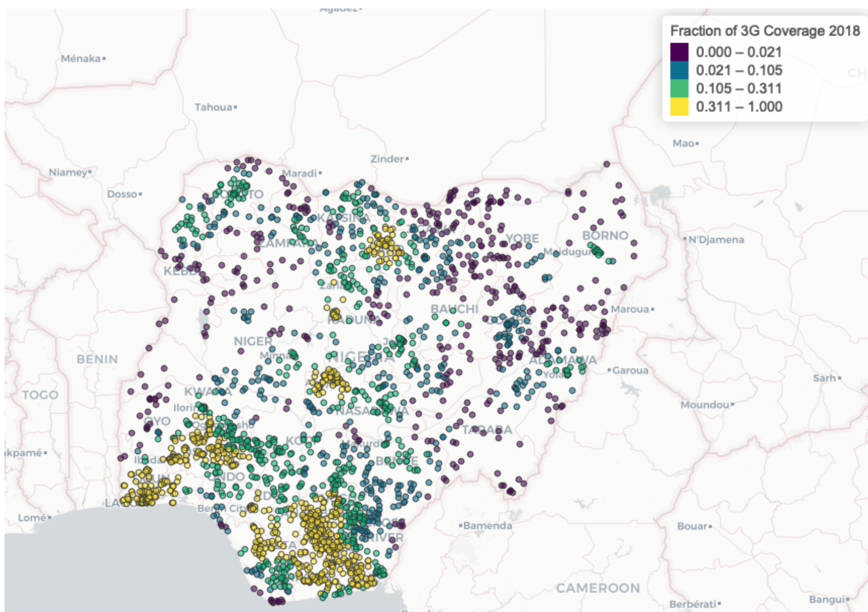

Figure 2: Mobile Coverage in 2018

Nigerian Demographic and Health Surveys Program (NDHS)

Our study sample comes from two waves of the Nigerian Demographic and Health Surveys Program (NDHS) in 2013 and 2018, when 3G mobile networks started to expand across the country. NDHS provides individual level data on women's fertility decisions as well as information on education, wealth, employment, access to mobile phone, and sources from which women access information. The DHS employs a rigorous methodology for sampling and data collection. It uses a stratified two-stage cluster sampling design to ensure national representativeness. In the first stage, enumeration areas (EAs) are selected with probability proportional to size within each sampling stratum. These EAs are usually census enumeration areas, statistical enumeration districts, or villages. In the second stage, a fixed number of households (typically 25-30) are randomly selected from each EA using systematic sampling methods based on updated household listings.

The maps illustrate the geographic distribution of NDHS survey clusters across Nigeria, with each red dot representing a survey cluster location Figures 3 and 4. As shown, the survey provides comprehensive nationwide coverage across all 36 states and the Federal Capital Territory, with particularly dense sampling in the more populous southern regions, especially in the Niger Delta and southeastern states. The northern states of Sokoto, Katsina, Zamfara, and Borno show comparatively fewer sampling points, reflecting their lower population density and potentially more challenging survey conditions.

The 2013 NDHS surveyed 38,948 households and collected data from 38,522 women of reproductive age (15-49 years), while the 2018 NDHS included 41,821 households and 41,668 women. The overall household response rate was 99% in 2013 and 99.3% in 2018, while the women's response rate was 97.6% in 2013 and 99.0% in 2018, indicating exceptional survey quality and coverage. By utilizing both survey waves, we can observe changes in fertility outcomes and mobile phone access during a critical period of 3G network expansion in Nigeria. The spatial distribution of survey clusters also enables us to match respondent locations with geospatial data on mobile network coverage from Collins Bartholomew Mobile Coverage Explorer, creating a rich dataset that links individual demographic characteristics with local connectivity infrastructure.

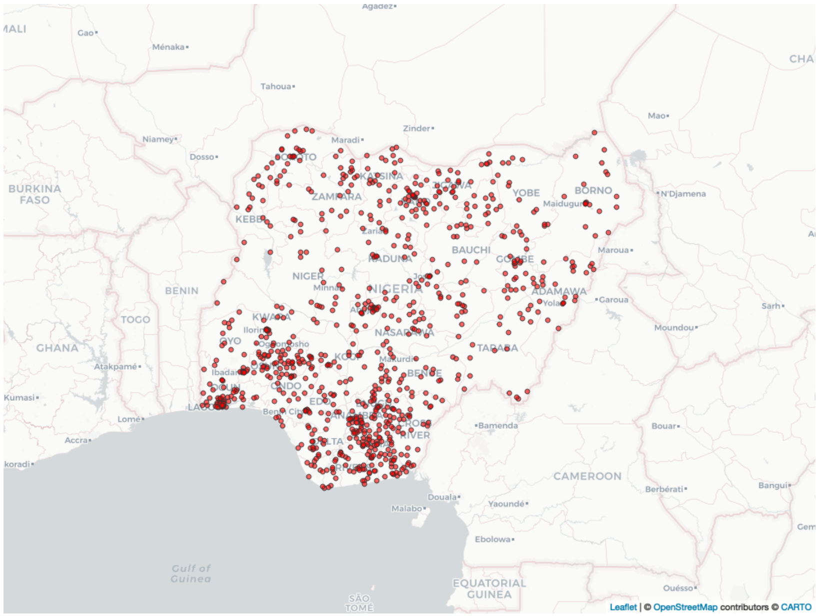

Figure 3: DHS Cluster Distribution in 2013

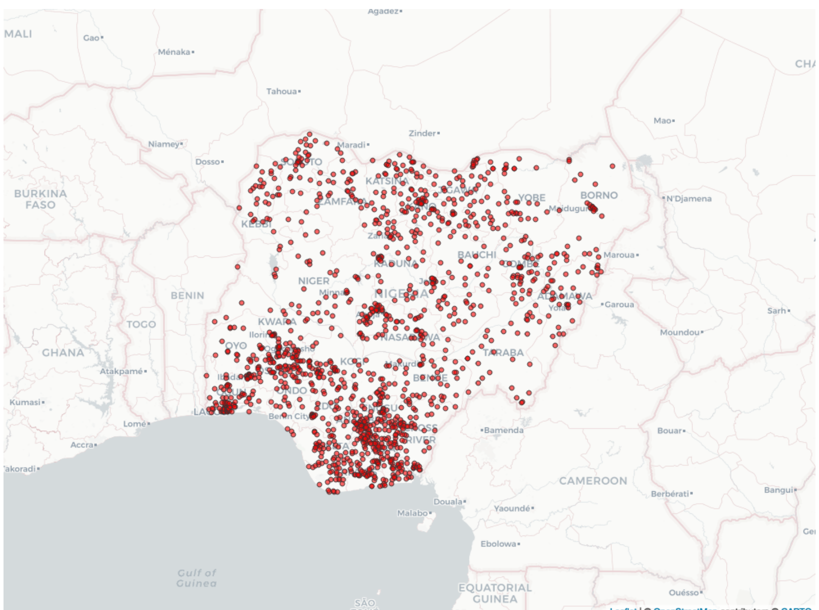

Figure 4: DHS Cluster Distribution in 2018

Female Fertility

The dataset contains individual-level birth history panels, which are completed during the survey year by all respondents who have experienced at least one birth. Based on these panels, I reconstruct comprehensive birth histories and generate annual dummy variables that take a value of 1 if an individual gave birth in a given year and 0 otherwise. Individuals with no recorded births are assigned values of 0 for all years in the panel.

Infant Mortality

Infant mortality is the death of an infant before his or her first birthday. A variety of evidence suggests that access to technology-intensive post-birth medical care should affect mortality risks during the neonatal period, rather than during the postneonatal period. Almond et al. (2010) analyze the mortality consequences of incremental increases in medical expenditures for at-risk infants (including NICU admission as well as other expenditures), and find that the mortality benefits of additional medical care are concentrated in the first 28 days of life. Therefore, we include additional two measurement for infant mortality: (1) neonatal mortality: deaths in the first 28 days; (2) postneonatal mortality: deaths in first 29 days to 12 months.

In addition, given the broad literature suggesting that early-life interventions can have long-run impacts, we next examine if the health gains from accessing to internet translated into reductions in mortality before 3 years old for those exposed to 3G around the time of their birth.

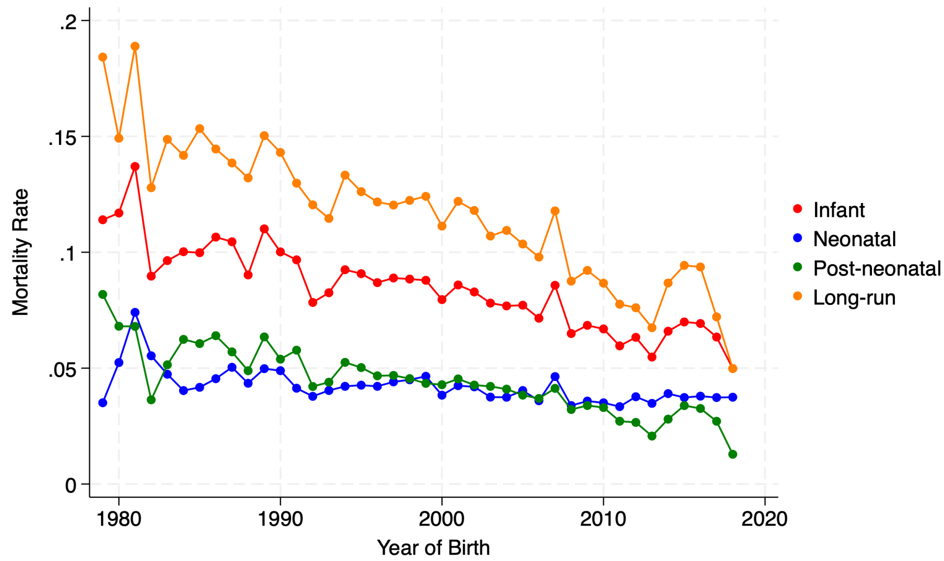

Figure 5: Child Mortality Over Time

Empirical Approach

Female Fertility

We use linear regression model and to account for infrastructure development patterns, the model include both individual fixed effects and state-year interaction terms.

$$\text{Birth}_{ic,t} = \beta_0 + \beta_1 \text{3GCoverage}_{c,t-1} + \beta_2 \text{X}_{ic,t-1} + \beta_3 \text{Weather}_{c,t-1} + \lambda_i + \tau_t * \pi_s + \epsilon_{ic,t} \qquad (1)$$

where t is year from 2013 to 2018. $Birth_{ic,t}$ is a binary variable indicating whether female i gives birth in time t; $3GCoverage_{c,t-1}$ represents the fraction of 3G coverage in a year $t-1$ within cluster c; $X_{ic,t-1}$ is a vector of time-variant individual control variables, including total number of birth and preceding years of last birth in year $t-1$. $Weather_{c,t-1}$ is level of climate variables in $t-1$. Climate covariates include precipitation, solar radiation, wind speed, vapour pressure, temperature and rain full level. λ_i represents individual fixed effects,

τ_t represents year fixed effects, π_i represents state fixed effects, and ε_{it} is the error term.

In this specification, we also substitute local government area fixed effects for individual-level fixed effects and omit individual covariates from the model.

Infant Mortality

We first restrict the sample to individuals who had children in any given year from 2012 to 2018. Next, we determine whether the child survived and, if not, record the time of death. Using this information, we calculate infant mortality at the individual level and include variables for neonatal, postnatal mortality and long-run mortality.

we address a critical selection problem, as we only observe the status of children whose mothers gave birth. Given our expectation that mortality is higher in areas with lower mobile coverage, and that these areas tend to have higher birth rates, the assumption of missing at random is clearly inappropriate and could potentially bias estimates of the effect of mobile coverage. Therefore, we estimate binary response panel data models with sample selection and self-selection using the methodology proposed by Semykina and Wooldridge (2018). This approach allows us to disentangle the effects of digital connectivity from other development indicators and account for selection bias in our analysis of infant mortality.

We analyze infant mortality outcomes while accounting for the non-random nature of birth decisions, as we only observe infant mortality for women who give birth. The selection equation models the woman's decision to give birth:

$$\begin{aligned} s_{it}^* &= z_{it}\delta + c_{i2} + u_{it2} \\ s_{it} &= 1[s_{it}^* > 0] \end{aligned} \tag{2}$$

Where s_{it}^* represents the latent propensity for woman i to give birth in period t, and s_{it} is the observed binary birth outcome. The vector z_{it} includes 3G coverage in the year before giving birth, climate covariates, the number of previous children, and the preceding years of giving birth during pregnancy. For exclusion restrictions, we utilize information on barrier contraception methods, creating a binary indicator that equals 1 if a woman reports using any barrier method of contraception. Specifically, we define a woman as using barrier methods if she uses male condoms, diaphragms, female condoms, or contraceptive foam/jelly. These physical barrier methods prevent pregnancy but would not directly influence infant mortality if conception does occur. We also include indicators for male sterilization and withdrawal methods. These contraceptive choices affect the likelihood of conception but should not directly influence infant mortality once birth occurs, making them valid exclusion restrictions.

The outcome equation for infant mortality is formulated as:

$$\begin{aligned} y_{it}^* &= x_{it}\beta + c_{i1} + u_{it1} \\ y_{it} &= 1[y_{it}^* > 0] \quad \text{observed only when } s_{it} = 1 \end{aligned} \tag{3}$$

Where y_{it}^* is the latent propensity for infant mortality, and y_{it} is the observed infant mortality outcome. The vector x_{it} includes the key explanatory variable of interest, weather controls from the previous year, individual-level controls, and child-specific characteristics. The term c_{i1} represents an unobserved individual effect influencing infant mortality, while u_{it1} is an idiosyncratic error.

To account for correlation between unobserved effects and explanatory variables, we implement the Mundlak correction:

$$\begin{aligned} c_{i1} &= \eta_1 + \bar{z}_i\xi_1 + a_{i1} \\ c_{i2} &= \eta_2 + \bar{z}_i\xi_2 + a_{i2} \end{aligned} \tag{4}$$

Where $\bar{z}_i$ represents cluster and individual time means of explanatory variables, while a_{i1}

and a_{i2} are random components uncorrelated with z_{it}. This approach allows for correlation between unobserved heterogeneity and observed characteristics.

The error structure follows a normal distribution:

$$(u_{it1}, u_{it2}, a_{i1}, a_{i2}) \sim \text{Normal}(0, \Sigma) \tag{5}$$

With correlation parameter:

$$\rho = \text{Corr}(v_{it1}, v_{it2}) \quad \text{where } v_{it1} = a_{i1} + u_{it1}, \quad v_{it2} = a_{i2} + u_{it2} \tag{6}$$

This theoretical setup properly accounts for selection bias, unobserved heterogeneity, and the relationship between 3G coverage and infant mortality outcomes while incorporating the exclusive contraceptive method variables as exclusion restrictions. By modeling both the selection and outcome processes jointly, we can obtain consistent estimates of the effect of mobile internet coverage on infant mortality despite the inherent selection challenges.

Main Result

Impact of Mobile Internet Coverage on Birth History: Full Sample

Table 1 presents the estimated impact of mobile internet coverage on women's birth history using our two-way fixed effects specification. We measure mobile coverage using three different buffer distances (20km, 30km, and 40km) to test the robustness of our results to alternative measures of connectivity and to investigate potential dose-response relationships.

The results indicate a consistent and statistically significant negative relationship between mobile internet coverage and birth outcomes across all specifications. For the 20km buffer (Panel A), the coefficient on mobile coverage ranges from -0.263 to -0.321, with the magnitude increasing as we include more stringent fixed effects. In our most comprehensive specification (column 3), which includes individual, state-by-year, and age cohort fixed effects, a one-unit increase in mobile coverage is associated with a 0.321 reduction in birth outcomes (p¡0.01).

Similar patterns emerge when examining the 30km buffer zone (Panel B), with coefficients ranging from -0.208 to -0.251 across specifications. The 40km buffer results (Panel C) show slightly smaller but still highly significant effects (-0.168 to -0.178), suggesting that the impact of mobile internet attenuates with distance—an expected pattern if information access is the primary mechanism.

The consistency of these findings across different buffer distances and fixed effects specifications provides strong evidence for the robustness of the relationship. The inclusion of individual fixed effects controls for time-invariant characteristics of women that might affect both mobile coverage and fertility decisions. The state-by-year fixed effects account for region-specific temporal trends that could confound our estimates, while age cohort fixed effects control for lifecycle patterns in reproductive behavior.

Interestingly, the magnitude of the effect appears to decrease as the buffer radius increases (from 20km to 40km), which aligns with theoretical expectations regarding signal strength and actual accessibility. This spatial gradient provides additional support for a causal interpretation of our findings, as it suggests that women with better access to mobile internet (those within closer proximity to coverage) experience stronger effects on their reproductive choices.

The control mean values (0.220, 0.223, and 0.228 for 20km, 30km, and 40km buffers, respectively) represent the average birth outcomes when mobile coverage is absent. Relative to these baseline values, our estimates suggest that full mobile coverage could reduce birth outcomes by approximately 145% (using the 20km buffer estimate), highlighting the substantial magnitude of this relationship.

Our findings are consistent with the hypothesis that increased access to information through mobile internet enables women to make more informed reproductive health decisions, potentially by increasing knowledge about family planning methods, changing social norms regarding family size, or expanding economic opportunities that affect fertility preferences.

Heterogeneous Effects Among Adolescents

Table 2 presents results from our analysis focusing on a particularly vulnerable subgroup: adolescent women aged 15-19 years. This demographic is of special interest given their elevated risk for pregnancy complications, limited economic opportunities, and restricted access to reproductive health information.

The estimates reveal substantially larger effects of mobile internet coverage on birth outcomes for adolescents compared to the full sample. For the 20km buffer (Panel A), the coefficients range from -0.508 to -0.568, roughly twice the magnitude observed in the full sample. This pattern persists across the 30km buffer (-0.374 to -0.417) and 40km buffer (-0.265 to -0.281) specifications. All coefficients remain highly statistically significant (p¡0.01), with the exception of the 40km buffer under the most stringent fixed effects specification, which is significant at the 5The amplified effect sizes for adolescents suggest that this demographic may be particularly responsive to the information and opportunities provided by mobile internet access. The lower baseline fertility rates in areas without coverage (control means of 0.161-0.165 for adolescents versus 0.220-0.228 in the full sample) indicate that adolescent childbearing is less common overall, but the proportional impact of mobile coverage is much larger. For instance, using the 20km buffer estimate from column 5 (-0.568), full mobile coverage would predict a reduction in adolescent birth outcomes by approximately 353% relative to the control mean.

These findings have important policy implications, as they suggest that expanding mobile internet infrastructure could be particularly effective in addressing adolescent pregnancy rates. The mechanisms may include improved access to sexual education, greater awareness of contraceptive options, enhanced social connectivity that alters norms around early childbearing, or increased educational and economic aspirations that motivate delayed childbearing.

Infant Mortality

The results from our sample selection-corrected model of infant mortality are presented in Table 3. After accounting for potential selection bias in birth outcomes, we find no statistically significant relationship between 3G mobile network coverage and infant mortality. The coefficient on 3G coverage (0.1245) is positive but imprecisely estimated, with a standard error of 0.3046. This suggests that the expansion of mobile internet infrastructure does not have a direct effect on infant survival once we account for its influence on fertility decisions.

Our methodological approach explicitly tests for selection bias through the inclusion of year-specific inverse Mills ratio terms. The coefficients on these terms vary in magnitude and direction across years, with imr in year 3 showing the largest negative effect (-0.3351). However, the joint test of significance for these selection correction terms yields a p-value of 0.3973, indicating that we cannot reject the null hypothesis of no selection bias at conventional significance levels. This finding is methodologically important as it suggests that while concerns about selection bias are theoretically justified, empirically the bias may be less severe than anticipated in this particular context.

The large sample size (36,266 observations) provides adequate statistical power for our analysis, and the model controls for a comprehensive set of individual, child-specific, and environmental factors. The negative constant term (-1.8877) reflects the generally low baseline probability of infant mortality in our sample, consistent with the declining trend in child mortality observed in Nigeria over the study period.

These results contrast with our findings on fertility decisions, where 3G coverage showed significant negative effects. This pattern suggests that mobile connectivity may influence demographic outcomes primarily through fertility decisions rather than through direct effects on infant survival. The pathways through which information access affects reproductive health may be more consequential for decisions about whether and when to have children than for child health outcomes after birth.

Conclusion

This study provides robust evidence that the expansion of 3G mobile network coverage in Nigeria has had significant impacts on fertility decisions, though our analysis suggests a more nuanced relationship with infant mortality outcomes. Our findings demonstrate that improved access to information and services through mobile connectivity enables women to make more informed reproductive health choices, leading to reduced birth rates—particularly among vulnerable adolescents.

The consistently stronger effects observed at closer proximities to mobile coverage infrastructure, combined with our methodological approaches addressing endogeneity and selection concerns, support a causal interpretation of the relationship between 3G coverage and fertility decisions. The substantially larger effects on adolescent fertility suggest that digital connectivity may be particularly valuable for younger women who face greater information constraints and have more limited access to traditional reproductive health resources.

Our selection-corrected models for infant mortality, however, do not detect a statistically significant direct relationship between 3G coverage and child survival outcomes after accounting for fertility decisions. The absence of significant selection bias in our infant mortality models suggests that the primary pathway through which 3G coverage influences demographic outcomes may be through its effects on fertility decisions rather than direct effects on child survival.

From a theoretical perspective, our results align with models emphasizing the role of information access in fertility decision-making. The observed patterns support our conceptual framework linking digital connectivity to reproductive outcomes primarily through direct information effects and socioeconomic empowerment rather than through healthcare utilization for infant care.

From a policy standpoint, these findings suggest that investments in telecommunications infrastructure in developing regions may yield significant demographic dividends beyond their economic returns, particularly in reducing fertility rates among high-risk groups. Policymakers seeking to address high fertility rates might consider digital connectivity expansion as a complementary strategy to traditional reproductive health interventions. The particularly strong effects among adolescents highlight the potential for targeted digital resources to address vulnerable populations.

Future research should explore whether longer-term exposure to mobile connectivity might eventually translate into improved child survival outcomes, investigate potential heterogeneity across different socioeconomic groups, and examine the specific digital resources and services most effective at improving reproductive health outcomes. As mobile technologies continue to evolve, understanding how these digital pathways shape demographic outcomes will remain crucial for effective policy design in developing countries.

Tables

Table 1: Impact of Mobile Internet Coverage on Birth History - Full Sample

Panel A: 20km Buffer			
	(1)	(2)	(3)
Mobile Coverage	-0.263***	-0.281***	-0.321***
	(0.028)	(0.040)	(0.040)
Observations	222,086	222,086	222,086
R-squared	0.388	0.392	0.411
Fixed Effects:			
Individual	Yes	Yes	Yes
GSMYEAR	Yes	No	No
State*GSMYEAR	No	Yes	Yes
Age Cohort	No	No	Yes
Control Mean	0.220	0.220	0.220
Panel B: 30km Buffer			
Mobile Coverage	-0.208***	-0.226***	-0.251***
	(0.024)	(0.043)	(0.043)
Observations	222,086	222,086	222,086
R-squared	0.388	0.392	0.411
Fixed Effects:			
Individual	Yes	Yes	Yes
GSMYEAR	Yes	No	No
State*GSMYEAR	No	Yes	Yes
Age Cohort	No	No	Yes
Control Mean	0.223	0.223	0.223
Panel C: 40km Buffer			
Mobile Coverage	-0.168***	-0.160***	-0.178***
	(0.022)	(0.047)	(0.049)
Observations	222,086	222,086	222,086
R-squared	0.388	0.392	0.411
Fixed Effects:			
Individual	Yes	Yes	Yes
GSMYEAR	Yes	No	No
State*GSMYEAR	No	Yes	Yes
Age Cohort	No	No	Yes
Control Mean	0.228	0.228	0.228

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the cluster level. Control Mean represents the mean value when GSMCOVER=0. Control variables include total number of children, preceding year of giving birth during pregnancy, and climate covariates (precipitation, solar radiation, wind speed, vapor pressure, and temperature).

Table 2: Impact of Mobile Internet Coverage on Birth History - Age between 15 and 19

Panel A: 20km Buffer			
	(1)	(3)	(5)
Mobile Coverage	-0.508***	-0.577***	-0.568***
	(0.048)	(0.074)	(0.076)
Observations	51,085	51,085	51,085
R-squared	0.433	0.444	0.458
Fixed Effects:			
Individual	Yes	Yes	Yes
GSMYEAR	Yes	No	No
State*GSMYEAR	No	Yes	Yes
Age Cohort	No	No	Yes
Control Mean	0.161	0.161	0.161
Panel B: 30km Buffer			
	(7)	(9)	(11)
Mobile Coverage	-0.374***	-0.426***	-0.417***
	(0.049)	(0.091)	(0.094)
Observations	51,085	51,085	51,085
R-squared	0.432	0.443	0.457
Fixed Effects:			
Individual	Yes	Yes	Yes
GSMYEAR	Yes	No	No
State*GSMYEAR	No	Yes	Yes
Age Cohort	No	No	Yes
Control Mean	0.163	0.163	0.163

Panel C: 40km Buffer			
	(13)	(15)	(17)
Mobile Coverage	-0.281***	-0.274***	-0.265**
	(0.047)	(0.090)	(0.110)
Observations	51,085	51,085	51,085
R-squared	0.432	0.443	0.456
Fixed Effects:			
Individual	Yes	Yes	Yes
GSMYEAR	Yes	No	No
State*GSMYEAR	No	Yes	Yes
Age Cohort	No	No	Yes
Control Mean	0.165	0.165	0.165

Notes: Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors are clustered at the cluster level. Control Mean represents the mean value when GSMCOVER=0. Control variables include total number of children, preceding year of giving birth during pregnancy, and climate covariates (precipitation, solar radiation, wind speed, vapor pressure, and temperature).

Table 3: Probit Model of Infant Mortality with Selection Correction

VARIABLES	(1) Infant Mortality
Mobile Coverag	0.1245
	(0.3046)
imr_year_1	-0.1106
	(0.1578)
imr_year_2	-0.0100
	(0.2024)
imr_year_3	-0.3351
	(0.2240)
imr_year_4	-0.1232
	(0.2479)
imr_year_5	0.2990
	(0.2634)
imr_year_6	0.1949
	(0.3060)
Constant	-1.8877
	(1.2248)
Observations	36,266
Selection Test p-value	0.3973
Selection Test df	6

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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