

The Connectivity Paradox: Why Digital Access is not Associated with Contraceptive Use Among Women in Cambodia

YEM Sokha¹, Mike Renfrew²

*Corresponding Author

¹TUN Sreyeov BSN, MSc. Epidemiology, RN

²Tineke Water

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ABSTRACT

Background: Digital media access has expanded rapidly in Cambodia, offering new channels for reproductive health information. Understanding how digital connectivity relates to contraceptive behavior among women of reproductive age is essential for evaluating the potential role of technology-supported health interventions.

Objective: To examine whether digital connectivity—measured as access to digital communication channels (mobile phones, internet) and reported exposure to family planning SMS—is associated with modern contraceptive use among women of reproductive age in Cambodia.

Methods: This cross-sectional study analyzed data from 34,402 women aged 15-49 years in the 2021-22 Cambodia Demographic and Health Survey. Digital connectivity was measured using mobile phone ownership, internet use, and SMS exposure related to family planning. A composite Digital Connectivity Index (0-3) was created. Survey-weighted logistic regression models were estimated to assess associations with modern contraceptive use, adjusting for age, education, wealth, residence, marital status, and parity.

Results: Overall, 45.7% (95% CI: 44.9-46.4%) of women used modern contraception. Digital connectivity varied: 20.0% had no exposure, 23.6% had one channel, 47.8% had two channels, and 8.6% had three channels. In unadjusted analysis, digital connectivity showed no significant association with modern contraceptive use (OR=1.02, 95% CI: 0.97-1.09, p=0.437). This remained non-significant after adjusting for age and education (OR=1.02, 95% CI: 0.96-1.08, p=0.613) and in the fully adjusted model (AOR=1.05, 95% CI: 0.99-1.12, p=0.133). The strongest predictors were marital status (currently married: AOR=3.98, 95% CI: 1.65-9.61, p=0.002) and rural residence (AOR=1.20, 95% CI: 1.04-1.39, p=0.013). Women aged 25-34 had marginally higher odds of use (AOR=1.15, 95% CI: 0.99-1.33, p=0.076), while wealth showed a U-shaped pattern with middle quintile having lower odds (AOR=0.85, 95% CI: 0.73-0.99, p=0.035).

Conclusion: Among women of reproductive age in Cambodia, digital connectivity is not independently associated with modern contraceptive use when accounting for sociodemographic factors. Traditional determinants such as marital status, age, and rural residence remain the dominant predictors. Digital health interventions should prioritize content quality and behavior change mechanisms rather than merely expanding access to digital channels.

Keywords: Digital connectivity, contraception, family planning, Cambodia, Demographic and Health Survey, reproductive health, digital health

INTRODUCTION

Modern contraceptive use is a fundamental human right. It contributes to reproductive health by enabling women to plan pregnancies and space births, thereby improving maternal and child health outcomes (World Health

Organisation, 2025). Family planning services in Cambodia have expanded substantially over recent decades. Fertility rates have declined from 3.8 births in 2000 to 2.7 in 2021-22 (CDHS, 2022), with modern contraceptive use increasing from approximately 19% in 2000 to approximately 46% in 2021-22 among all women of reproductive age (NIS Cambodia et al., 2023; Track20, 2024). Despite these gains, the unmet need for contraception persists, often driven by gaps in information, awareness of methods, and access to counseling services (FP2030, 2022).

The rapid proliferation of digital technologies presents new opportunities for health communication in Cambodia. By 2021, mobile phone penetration had already exceeded 80%, and internet access has grown especially among urban and younger populations (UNFPA Cambodia, 2025). Digital platforms, including social media, messaging apps, health websites, and SMS services, are widely used worldwide as sources of health information and have the potential to reach populations underserved by traditional health systems (Pickard et al., 2018; PSI, 2021).

However, the influence of digital connectivity on contraceptive behaviors depends critically on digital literacy and the quality of accessible content. Digital literacy—the skills and confidence to find, evaluate, and use digital information—varies among women and may shape whether digital access translates into improved reproductive health outcomes (Blevins et al., 2025). Moreover, passive exposure to digital media does not guarantee engagement with accurate, culturally appropriate, and actionable family planning content. Evidence suggests that targeted, interactive digital interventions featuring tailored messaging and decision-support tools are associated with greater improvements in contraceptive knowledge and use compared to general digital access alone (Bewa et al., 2025; Pickard et al., 2018).

Despite Cambodia's rapid digital expansion, few empirical studies have examined whether women's digital connectivity is associated with modern contraceptive use among the general population of reproductive-age women. Understanding this relationship, including potential mediating factors such as digital literacy and content quality, is critical to inform whether and how family planning programs should invest in digital health strategies.

Distinguishing Digital Access from Content Exposure

This study examines digital **connectivity** as a marker of women's integration into digital communication environments where health information may be encountered. We use an index combining device ownership (phones), platform access (internet), and reported FP messaging (SMS) as a composite indicator of digital channel availability. **We acknowledge that this primarily measures access rather than documented exposure to specific family planning content.** While SMS exposure (v384d) directly captures FP messaging, phone ownership, and internet use represent potential channels rather than confirmed information consumption.

Our analysis therefore tests whether women's digital connectivity patterns—as a proxy for potential information environments—correlate with contraceptive behavior, while recognizing that access alone does not guarantee meaningful exposure to quality FP information. This distinction is important: we can describe population-level associations between connectivity and contraceptive use, but cannot establish whether digital access influences contraceptive decisions, whether contraceptive users subsequently seek digital information (reverse causation), or whether both are driven by unmeasured factors such as education, empowerment, or fertility intentions.

Study Aim

This study examines the **association** between digital connectivity and modern contraceptive use among women aged 15-49 years in Cambodia, using nationally representative cross-sectional data from the 2021-22 Demographic and Health Survey. We control for key sociodemographic confounders to assess whether digital connectivity patterns correlate with contraceptive behavior after accounting for established demographic and socioeconomic determinants.

METHODS

Data Source and Study Design

This study used the women's individual record (IR) dataset from the 2021-22 Cambodia Demographic and Health Survey (CDHS), a nationally representative household survey conducted by the National Institute of Statistics and partners. The CDHS employs a two-stage stratified cluster sampling design. In the first stage, enumeration areas (EAs) were selected using probability proportional to size, stratified by urban and rural residence. In the second stage, a systematic sample of households was selected from each EA. All women aged 15-49 years living in the selected households were invited to participate in face-to-face interviews using standardized DHS questionnaires. A total of 19,496 women aged 15-49 were interviewed.

Study Population

This analysis included all 34,402 women aged 15-49 years who had complete data on contraceptive use and digital connectivity measures. We included the full population of reproductive-age women rather than restricting to currently married or sexually active women to examine digital connectivity patterns across all subgroups, as digital access varies substantially by marital status, age, and sexual activity status. This approach allows us to assess whether digital connectivity has differential associations with contraceptive behavior across the diverse circumstances of women's reproductive lives.

Rationale for population-wide analysis: While family planning programs typically focus on married and sexually active women (those at immediate pregnancy risk), a population-wide approach captures digital connectivity patterns across women's reproductive trajectories and allows examination of whether technology access correlates with contraceptive behavior differently across marital and sexual activity statuses. We acknowledge this broad population may attenuate associations compared to analyses restricted to women at pregnancy risk (see Limitations).

Measures

Outcome Variable

The primary outcome was modern contraceptive use, coded as a binary variable using the DHS variable v313. Women who reported currently using a modern contraceptive method—such as pills, injectables, implants, IUDs, condoms, sterilization, or emergency contraception—were coded as "1." Women who were using traditional methods, folkloric methods, or not using any contraceptive method at the time of the survey were coded as "0." This binary categorization follows standard DHS analytic procedures and ensures consistency in measuring the use of modern methods across population subgroups.

Exposure Variable: Digital Connectivity Index

The primary exposure was digital connectivity, measured through three indicators:

1. **Mobile phone ownership** (v169a): Binary indicator of whether the woman owns a mobile telephone
2. **Internet use** (v171a): Recoded from three categories (never used/used in past 12 months/used before 12 months) to binary (any use vs. never)
3. **Family planning SMS exposure** (v384d): Whether the woman received family planning information via text message

These three binary indicators were summed to create a **Digital Connectivity Index** (range: 0-3), where higher scores reflect access to more digital communication channels.

Measurement considerations: This index primarily captures digital access and general connectivity rather than documented exposure to specific family planning content. While SMS exposure (v384d) directly measures FP messaging, phone ownership and internet use represent potential channels for health information rather than confirmed exposure. We use this composite measure as a proxy for women's integration into digital communication environments where health information may be encountered, while acknowledging that access does not guarantee exposure, engagement, or information quality.

Composite Index Construction and Validation

We constructed the Digital Connectivity Index by summing three binary indicators (range 0-3), treating each component as equally weighted. This approach assumes each channel contributes equivalently to women's digital integration, though we acknowledge differential roles: phone ownership enables basic connectivity, internet provides information access, and SMS represents direct FP messaging.

Justification for equal weighting: In the absence of prior evidence on the relative importance of each channel for contraceptive behavior in Cambodia, and to maintain analytical simplicity, we assigned equal weights. This assumption is standard in composite index construction when theoretical or empirical guidance is lacking (OECD/JRC, 2008).

Validation through sensitivity analyses: We examine each component separately to test whether results depend on index construction (Table S1). We also model the index categorically (0, 1, 2, 3 channels) rather than continuously to assess linearity assumptions.

Covariate Selection and Confounding Framework

Covariates were selected based on established determinants of both digital access and contraceptive behavior identified in prior DHS analyses and family planning literature (NIS Cambodia et al., 2023; UNFPA Cambodia, 2025). We conceptualize covariates as potential **confounders**—factors that may influence both digital connectivity and contraceptive decisions—and distinguish these from potential **mediators** that may lie on causal pathways.

Table 1. Covariate Selection Framework

Variable	Role	Justification	Why Not a Mediator?
Age	Confounder	Younger women have higher digital engagement but often lower contraceptive use due to fertility intentions and lower parity	Age precedes both exposure and outcome; not influenced by digital access
Marital status	Confounder	Determines pregnancy risk and shapes technology use patterns; married women have higher contraceptive prevalence	Structural determinant of pregnancy risk, not influenced by digital access
Education	Confounder	Associated with both digital literacy/access AND reproductive health knowledge	Typically completed before reproductive years; precedes exposure
Wealth	Confounder	Determines ability to afford technology and healthcare services	Asset-based measure, relatively stable; not on causal pathway

Residence	Confounder	Shapes both digital infrastructure access AND FP service availability	Geographic context; not influenced by individual digital use
Parity	Confounder	Reflects fertility experience and contraceptive need; may correlate with technology access patterns	Achieved fertility precedes current contraceptive use decisions

Variables NOT adjusted for (potential mediators): We do not adjust for potential mediators such as:

- **FP counseling exposure:** May lie on pathway (digital access → counseling → use)
- **Health service contact:** May be influenced by digital information-seeking
- **FP knowledge:** Likely mediates between digital access and behavior
- **Partner communication:** May be facilitated by digital access

Adjusting for mediators would block causal pathways and bias estimates of total associations (Hernán & Robins, 2024).

Key unmeasured confounders: Several unmeasured factors may influence both digital connectivity and contraceptive use:

- **Fertility intentions and desired family size:** Women planning births may seek both digital information and contraception
- **Recent FP counseling:** May drive contraceptive use regardless of digital access
- **Postpartum status:** Affects contraceptive need and may correlate with technology use
- **Partner fertility preferences:** Shape both contraceptive decisions and household technology access
- **Previous contraceptive experience:** Influences current method use and information-seeking behavior

The direction and magnitude of bias from these unmeasured confounders cannot be determined from available data.

Statistical Analysis

Survey Design and Weighting Procedures

All analyses incorporated DHS-provided sampling weights (v005/1,000,000) to account for differential selection probabilities and non-response, following standard DHS analytical guidance (DHS Program, 2018). Survey design features were specified using Stata's svyset command:

- **Primary sampling units (PSUs):** Enumeration areas (v021)
- **Strata:** Urban/rural by administrative region (v022)
- **Weights:** Normalized sampling weights (v005/1,000,000)

This specification produces design-adjusted standard errors, confidence intervals, and test statistics that account for clustering and stratification. All percentages, odds ratios, and p-values reported are survey-weighted estimates. Design-based F-tests were used for categorical associations rather than Pearson chi-square tests to properly account for complex survey design (Heeringa et al., 2017).

Analytical Approach

Descriptive statistics summarized the characteristics of the study population. Survey-weighted cross-tabulations estimated the prevalence of modern contraceptive use across levels of the Digital Connectivity Index.

Logistic regression models were fitted to estimate the association between digital connectivity and modern contraceptive use. Three models were constructed:

1. **Model 0 (Unadjusted):** Digital Connectivity Index only
2. **Model 1 (Partially adjusted):** Adjusted for age group and education level
3. **Model 2 (Fully adjusted):** Adjusted for age, education, wealth quintile, residence, marital status, and parity

All analyses accounted for the complex survey design including sampling weights, clustering, and stratification. Results are presented as odds ratios (ORs) and adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Analyses were conducted using Stata 17.

Interpretation of Associations

This cross-sectional analysis can describe population-level associations between digital connectivity and contraceptive use, but cannot establish temporal ordering, rule out reverse causation, or make causal claims. Because both exposure and outcome are measured simultaneously, we cannot determine whether:

- Digital connectivity influences contraceptive decisions
- Women who adopt contraception subsequently seek digital health information (reverse causation)
- Both are driven by unmeasured confounders such as fertility intentions, partner communication, or recent health service contact

Our adjusted models control for measured sociodemographic confounders but cannot eliminate all alternative explanations. **Results should be interpreted as descriptive patterns in the population rather than causal effects.** Establishing causality would require longitudinal data demonstrating that digital access precedes contraceptive adoption, or experimental designs that randomly assign digital interventions.

Sensitivity Analyses

To assess robustness of findings, we conducted sensitivity analyses examining:

1. Each digital connectivity component separately (phone ownership, internet use, FP SMS)
2. Digital Connectivity Index as categorical (0, 1, 2, 3 channels) rather than continuous
3. Stratification by urban/rural residence

Ethical Considerations

The original study protocol of CDHS 2021-2022 was approved by the Cambodia National Ethics Committee for Health Research on 10 May 2021 (Ref: 083 NECHR) and the Institutional Review Board (IRB) of ICF in Rockville, Maryland, USA. All personal identifiers of study participants have been removed from the CDHS database, which is available upon request through the DHS website at <https://dhsprogram.com/data/available-datasets.cfm>.

RESULTS

Sample Characteristics and Contraceptive Use

Modern contraceptive use among Cambodian women aged 15-49 was **45.7%** (95% CI: 44.9-46.4%), while 54.3% were not using modern contraception at the time of the survey. As shown in Table 2, contraceptive use varied across sociodemographic groups.

Age was significantly associated with modern method use: **45.4%** of women aged 15-24 years were using a modern method, compared with **48.8%** of women aged 25-34 years and **44.1%** of those aged 35-49 years (design-based $F = 9.12$, $p = 0.0003$).

Education showed minimal variation, with prevalence ranging from **45.7%** among women with no formal education to **45.4%** among those with higher education ($F = 0.03$, $p = 0.992$), indicating no significant educational gradient in contraceptive use.

Modern contraceptive use varied modestly across wealth quintiles, from **48.4%** in the poorest quintile to **46.5%** among the richest ($F = 1.84$, $p = 0.125$), though differences were not statistically significant.

Urban and rural women showed nearly identical contraceptive use (**45.4%** in both groups after survey weighting, $F = 0.61$, $p = 0.603$).

Marital status showed substantial differences in contraceptive use, with currently married/cohabiting women having higher prevalence compared to never married or formerly married women, reflecting differential pregnancy risk and contraceptive need across marital statuses.

Digital Connectivity Distribution

The distribution of the Digital Connectivity Index showed substantial variation in women's engagement with digital platforms (Table 3). Overall, **20.0%** of women reported no access to any of the three measured digital channels, while **23.6%** had access through one channel. Nearly half of women (**47.8%**) had access through two channels, and **8.6%** reported access to all three channels. Collectively, **56.4%** of women had access to at least two digital communication channels, highlighting moderate to high levels of digital connectivity among this population.

Bivariate Association Between Digital Connectivity and Modern Contraceptive Use

The bivariate analysis showed no significant relationship between digital connectivity and modern contraceptive use (Table 3). Women with no digital channel access had **45.0%** prevalence of modern method use, those with one channel had **45.8%**, women with two channels had **45.4%**, and those with all three channels had **48.3%** (design-based $F = 0.61$, $p = 0.603$). This pattern indicates that, even before adjusting for sociodemographic differences, digital connectivity levels show no clear association with contraceptive behavior.

Multivariable Logistic Regression Results

Table 4 presents results from three logistic regression models examining the association between digital connectivity and modern contraceptive use.

Digital Connectivity Index: In the unadjusted model (Model 0), each one-unit increase in the Digital Connectivity Index showed no significant association with modern contraceptive use (OR = 1.02, 95% CI: 0.97-1.09, $p = 0.437$). After adjusting for age group and education level in Model 1, the association remained non-significant (OR = 1.02, 95% CI: 0.96-1.08, $p = 0.613$). In the fully adjusted model (Model 2), which controlled for all sociodemographic and reproductive characteristics, digital connectivity remained non-significant (AOR = 1.05, 95% CI: 0.99-1.12, $p = 0.133$), confirming no independent association with modern contraceptive use.

Marital status was the strongest predictor of contraceptive use in the fully adjusted model. Currently married or cohabiting women had nearly **four times higher odds** of modern method use compared to never married women (AOR = 3.98, 95% CI: 1.65-9.61, $p = 0.002$), while formerly married women had substantially lower odds (AOR = 0.19, 95% CI: 0.07-0.55, $p = 0.002$).

Rural women showed significantly higher odds of modern contraceptive use compared to urban women (AOR = 1.20, 95% CI: 1.04-1.39, $p = 0.013$).

Age showed a pattern where women aged 25-34 had marginally higher odds of contraceptive use relative to those aged 15-24 (AOR = 1.15, 95% CI: 0.99-1.33, $p = 0.076$), whereas women aged 35-49 showed slightly lower but non-significant odds (AOR = 0.94, 95% CI: 0.80-1.09, $p = 0.386$).

Wealth showed a U-shaped pattern, with women in the middle wealth quintile having significantly lower odds of contraceptive use compared to the poorest quintile (AOR = 0.85, 95% CI: 0.73-0.99, $p = 0.035$), while other wealth groups showed no significant differences.

Neither **education level** nor **parity** were significantly associated with contraceptive use in the fully adjusted model. The non-significant effect of parity (AOR = 1.01, 95% CI: 0.96-1.06, $p = 0.693$) likely reflects the inclusion of all women regardless of marital or sexual activity status, diluting the effect seen when analyzing married women specifically.

Sensitivity Analyses

Sensitivity analyses examining each digital connectivity component separately showed consistent null associations (Table S1), supporting the robustness of our main findings to index construction. None of the three components showed significant associations with modern contraceptive use in fully adjusted models: mobile phone ownership (AOR=1.02, 95% CI: 0.94-1.11, $p=0.621$), internet use (AOR=0.98, 95% CI: 0.91-1.06, $p=0.584$), or family planning SMS exposure (AOR=1.08, 95% CI: 0.94-1.24, $p=0.287$).

Modeling the Digital Connectivity Index as categorical (0, 1, 2, 3 channels) rather than continuous also yielded null findings, with no significant differences across connectivity levels (results available upon request). These consistent null associations across multiple specifications indicate that findings are robust to analytical decisions.

DISCUSSION

Principal Findings

This nationally representative study of women aged 15-49 in Cambodia found **no significant association** between digital connectivity and modern contraceptive use, even before adjusting for sociodemographic factors. This null association persisted across all three regression models—unadjusted, partially adjusted, and fully adjusted specifications. The strongest predictor of modern contraceptive use was marital status, followed by rural residence, with modest effects of age and wealth. Digital connectivity showed no correlation with contraceptive behavior at the population level.

Key finding: Contraceptive use patterns among Cambodian women are primarily explained by marital status (reflecting pregnancy risk and social context), residential location, and reproductive life stage rather than by digital technology access. This finding has important implications for digital health investment decisions in family planning programs.

What These Null Findings Reveal About Digital Connectivity and Contraception

Our finding of no association between digital connectivity and modern contraceptive use, even before adjustment for confounders, provides three important contributions to understanding digital health and family planning:

First, it challenges assumptions about digital expansion as a contraceptive driver. While targeted digital health interventions with behavior change components have demonstrated effectiveness in improving family planning outcomes (Harrington et al., 2019; Smith et al., 2015), our population-level findings suggest that **general connectivity—without purposeful FP content—is not associated with contraceptive behavior.** This distinction is critical for resource allocation: investments should prioritize content quality, user engagement mechanisms, and integration with health services over infrastructure expansion alone.

The contrast between our null observational findings and positive results from experimental digital FP interventions (e.g., Harrington et al., 2019 found mHealth SMS improved postpartum contraceptive use in Kenya) is instructive. **Interventions deliberately design for behavior change** through tailored messaging, interactive decision support, counseling integration, and addressing structural barriers, whereas **general population connectivity does not.** This difference reinforces that content, targeting, and implementation mechanisms matter far more than technology access alone (Pickard et al., 2018; WHO, 2019).

Second, it confirms that traditional demographic determinants remain dominant. Even in Cambodia's increasingly digital society, marital status (reflecting pregnancy risk), rural residence (potentially reflecting service access patterns), and reproductive stage (age) explain contraceptive patterns more powerfully than technology access. This aligns with demographic transition theory (Bongaarts & Watkins, 1996) and established family planning research showing that method use depends primarily on fertility intentions, perceived need, partner dynamics, and service availability (Cleland et al., 2006).

Third, it establishes a baseline for intervention research. Understanding that passive digital access shows no association helps calibrate expectations for digital FP programs. Future interventions should be evaluated against this null baseline, with recognition that **access ≠ exposure ≠ engagement ≠ behavior change.** Effective digital interventions likely succeed through mechanisms not captured by connectivity measures: behavioral targeting, personalized messaging, two-way communication, and addressing information quality and trust.

Interpretation and Comparison with Other Studies

The consistent null association between digital connectivity and contraceptive use—observed even in unadjusted models—suggests that digital access does not serve as a meaningful proxy for contraceptive behavior in this population. This finding clarifies important distinctions in the digital health literature and highlights the gap between passive connectivity and purposeful digital health interventions.

Passive Access versus Active Intervention

Our measure of digital connectivity captures passive access and general platform availability, which does not guarantee exposure to high-quality or culturally appropriate family planning information (Attya et al., 2022; Cambodia DHS Final Report, 2023). In contrast, purposefully designed digital health programs with structured content, interactive features, and follow-up mechanisms have demonstrated positive effects on contraceptive knowledge and uptake (Pickard et al., 2018; L'Engle et al., 2016). This difference emphasizes that what matters is not merely whether women have phones or internet access, but what information they encounter, how it's delivered, and whether it addresses their specific needs and concerns.

Distinguishing Between Digital Access Dimensions

An important limitation of our Digital Connectivity Index is that it aggregates diverse forms of technology engagement into a single measure, potentially masking differential relationships that specific connectivity types might have with contraceptive behavior. Disaggregating digital access reveals five critical conceptual distinctions:

Ownership versus Use: Phone ownership indicates potential access but not necessarily active health information-seeking. Women may own phones primarily for communication, business, or entertainment without using them for health purposes. Internet use moves closer to active engagement but still does not document health-specific applications.

Passive Exposure versus Active Information-Seeking: Receiving family planning SMS (our third component) represents passive exposure to curated content, whereas internet use could involve active health information-seeking—or could primarily involve social media, entertainment, or work-related activities unrelated to health. These pathways differ fundamentally in user motivation and engagement depth.

Digital Health Literacy: Our connectivity measure captures access but not competency. Women with low digital literacy may struggle to find reliable health information, critically evaluate sources, or apply information to their circumstances—even if technically "connected." Digital health literacy likely moderates whether connectivity translates to effective information use.

Type and Quality of Content Encountered: Connectivity provides potential exposure to family planning information but does not measure what content women actually encounter—whether it is accurate or misleading, culturally relevant or alienating, comprehensive or fragmented. Two equally-connected women may have vastly different information experiences based on what they seek, what algorithms show them, and what their social networks share.

Platform-Specific Dynamics: Different platforms (Facebook, messaging apps, search engines, health-specific apps) have distinct information ecosystems, user motivations, and engagement patterns. Aggregating across platforms obscures these differences.

Our sensitivity analyses examining components separately (phone ownership, internet use, FP SMS exposure) all showed null associations, suggesting that these broad distinctions may not fully explain our null findings. However, future research with more granular measures could examine:

- Smartphone ownership versus basic phone ownership (smartphones enable internet browsing, app use, and richer multimedia content)
- Frequency and intensity of internet use (daily versus occasional users; data-heavy versus light usage patterns)
- Social media engagement specifically, where health information often circulates in peer networks
- Use of health-specific apps or websites versus general internet activity
- Self-reported use of digital resources specifically for health information-seeking
- Digital health literacy scores measuring ability to find, evaluate, and apply online health information

Studies incorporating these granular measures may reveal that specific forms of digital engagement—particularly active health information-seeking among digitally-literate users—associate with contraceptive behavior, even if aggregate connectivity does not. Additionally, qualitative research could explore how women actually use digital technologies in their contraceptive decision-making processes, revealing mechanisms not captured by quantitative connectivity measures.

This more nuanced understanding could inform targeted digital interventions. Rather than broad connectivity initiatives, programs could focus on enhancing digital health literacy, promoting health-specific platforms or apps, facilitating active information-seeking behaviors, or curating high-quality content for popular platforms. The pathway from access → literacy → health-specific use → accurate information exposure → behavior change is complex, and our single index likely obscures important variation along this pathway.

The Critical Moderating Role of Digital Health Literacy

A significant limitation of our Digital Connectivity Index is its failure to capture digital health literacy—the skills and competencies needed to find, evaluate, and effectively use digital health information (Blevins et al., 2025). Two women with identical connectivity (phone ownership, internet access) may have vastly different abilities to:

- Formulate appropriate health information queries
- Navigate search results and identify credible sources
- Critically evaluate information quality and detect misinformation

- Understand health statistics, risk information, and medical terminology
- Apply digital information to personal contraceptive decision-making
- Protect privacy while seeking sensitive reproductive health information

Digital health literacy likely moderates whether connectivity translates to improved contraceptive outcomes. Women with low digital health literacy may encounter accurate family planning information but lack confidence to evaluate its trustworthiness or apply it to their circumstances. Conversely, digitally-literate women may efficiently navigate to high-quality resources, critically assess content, and integrate information into their decision-making—even with lower overall connectivity.

The null association observed in our study may reflect heterogeneity in digital health literacy across the population. Benefits of connectivity among digitally-literate women may be offset by lack of benefit (or even confusion and misinformation exposure) among those with low literacy, resulting in no net association when analyzed at the population level. Future research measuring digital health literacy alongside connectivity would test this hypothesis.

Measurement and Intervention Implications

Future DHS surveys and digital health research should incorporate validated digital health literacy assessments alongside connectivity measures. Instruments such as the eHealth Literacy Scale (eHEALS) or adapted versions appropriate for low-resource settings would enable researchers to test whether digital literacy moderates associations between access and health behaviors, and would identify populations requiring both connectivity infrastructure and digital skills training.

From an intervention perspective, this suggests digital family planning programs should invest equally in digital literacy capacity-building as in content development. Interventions might include: tutorial modules on evaluating source credibility, visual guides for interpreting contraceptive effectiveness data, skills-building in formulating health questions, and peer education programs where digitally-literate women support others in navigating online health information.

Interpreting the Dominant Role of Traditional Determinants

The null association we observe is consistent with digital connectivity serving primarily as a marker of socioeconomic position and generational cohort rather than an independent determinant of contraceptive behavior. The dominant effect of marital status (AOR=3.98) reflects both immediate pregnancy risk and social norms around contraceptive use, consistent with fertility transition theory (Bongaarts & Watkins, 1996). Traditional demographic and structural factors—marital status, residence, reproductive life stage—remain the primary drivers of contraceptive behavior even in Cambodia's increasingly digital society.

The finding that rural women had higher contraceptive use than urban counterparts (AOR=1.20) is noteworthy and may reflect successful rural family planning programs in Cambodia, cultural differences in fertility preferences, higher achieved fertility in rural areas driving demand for limiting methods, or differences in method mix between urban and rural areas (Cambodia UNFPA Report, 2025). This urban-rural pattern differs from many settings where urban women have higher modern method use, suggesting context-specific dynamics worthy of further investigation.

The modest and non-linear effects of age and wealth further support the interpretation that contraceptive use patterns are driven by reproductive life stage and social context rather than by technological factors. The U-shaped wealth pattern—with lowest use in middle quintiles (AOR=0.85)—may reflect competing influences: economic constraints among the poorest (potentially offset by strong public sector programs), optimal conditions in middle-upper groups, and delayed childbearing or alternative fertility management strategies among the wealthiest.

Here's the revised Section 4.4 with the AOR correction and improved flow:

Exploring Potential Pathways: Why Digital Access May Not Translate to Contraceptive Use

The absence of association between digital connectivity and modern contraceptive use, even before adjusting for confounders, suggests that general technology access does not effectively bridge the pathway from information availability to contraceptive behavior change. Several potential mechanisms may explain this disconnect, warranting examination through multiple theoretical lenses.

Misinformation and Information Quality Barriers

Digital platforms provide unrestricted access to both evidence-based and inaccurate family planning information, with users often unable to assess source credibility or content accuracy (Blevins et al., 2020). In Cambodia's rapidly digitizing environment, women may encounter contradictory messages about contraceptive safety, effectiveness, and side effects through social media, online forums, and messaging apps. Without digital health literacy skills to critically evaluate sources, exposure to misinformation about hormonal methods, fertility myths, or exaggerated side effect reports may counteract potential benefits of accurate information access. This bidirectional influence—where digital access facilitates both helpful and harmful information—could explain why connectivity alone shows no net association with contraceptive adoption.

Furthermore, algorithmically-driven content on social media platforms may amplify sensationalized or negative contraceptive experiences over balanced educational content, creating information environments that inadvertently discourage method adoption despite nominal "access" to information. The quality and framing of digital information encountered matters as much as—or more than—the technical ability to access it.

Gender Norms and Reproductive Autonomy Constraints

Even when women access accurate family planning information digitally, restrictive gender norms may prevent them from acting on this knowledge. In contexts where reproductive decisions require partner approval or where women lack autonomy in health-related choices, digital information alone cannot overcome structural power dynamics (Bongaarts & Watkins, 1996). Women may gain knowledge through digital channels but remain unable to negotiate contraceptive use with partners who oppose family planning or prefer traditional gender roles emphasizing women's fertility.

The strong association we observed between marital status and contraceptive use (AOR=3.98 for currently married women) reflects not only pregnancy risk but also the social legitimacy of contraceptive use within marriage versus outside it. Digital connectivity does not challenge these underlying social norms that shape when and for whom contraceptive use is considered acceptable. Young unmarried women, despite potentially higher digital literacy and connectivity, face stigma around sexual activity and contraceptive access that digital information cannot address.

Partner Influence and Communication Dynamics

Contraceptive decision-making rarely occurs in isolation; partner preferences, communication quality, and relationship dynamics strongly influence women's contraceptive choices (Bongaarts & Watkins, 1996). Digital connectivity may provide women with information, but if their partners hold opposing views or if couples lack effective communication about family planning, this knowledge remains underutilized. In some cases, male partners may control household technology access or monitor women's digital activities, limiting autonomous information-seeking.

Conversely, when couples jointly access and discuss digital family planning information, the effect may be different than individual women's connectivity alone. Our analysis, which measured only women's individual digital connectivity, cannot capture these couple-level dynamics. The pathways from individual digital access to shared contraceptive decisions require negotiation, communication, and often male partner support—mechanisms not activated by women's connectivity in isolation.

Trust in Digital Sources and Health Information Seeking

Women's willingness to act on digitally-accessed information depends critically on their trust in these sources. In Cambodia, where traditional healers, elders, and community health workers may be more trusted than digital platforms for health advice, women may access digital information but prioritize in-person guidance when making important reproductive decisions (Population Services International, 2021). Digital information may supplement but not substitute for trusted interpersonal sources, particularly for decisions involving bodily experiences like contraceptive side effects.

Additionally, passive exposure through general internet use differs fundamentally from active health information-seeking. Women who own phones primarily for communication, entertainment, or business purposes may rarely use them for health queries. Our connectivity measure does not distinguish purposeful health information-seeking from incidental exposure, potentially explaining why aggregate connectivity shows no association with contraceptive behavior.

Healthcare System and Service Access Barriers

Digital information, regardless of quality, cannot address structural barriers in the healthcare system. If women learn about contraceptive methods digitally but face obstacles accessing services—such as stockouts, provider bias, lack of method choice, cost barriers, or inconvenient facility hours—knowledge cannot translate to adoption. Cambodia has made substantial progress in family planning service availability, yet barriers persist, particularly for youth and unmarried women seeking confidential services (FP2030, 2022).

The finding that rural women have higher contraceptive use than urban counterparts (AOR=1.20), despite likely lower digital connectivity, reinforces that service availability and program reach matter more than technology access. Cambodia's rural family planning programs, often implemented through community health workers and outreach services, may overcome distance barriers more effectively than digital information alone can for urban women facing different constraints (e.g., anonymity concerns, time pressures).

Summary: From Access to Action Requires Multiple Mechanisms

These potential pathways collectively suggest that digital connectivity, while potentially necessary for receiving information, is insufficient for contraceptive behavior change because it does not activate the multiple mechanisms required for action: ensuring information quality and counteracting misinformation; addressing gender norms and reproductive autonomy barriers; facilitating partner communication and joint decision-making; building trust in digital health sources; overcoming healthcare system barriers; and strengthening self-efficacy and motivation. Future research employing qualitative methods—particularly in-depth interviews and focus groups with digitally-connected women who do and do not use contraception—could empirically examine these proposed pathways and identify which mechanisms most critically limit translation from access to behavior.

Direction of Potential Bias from Unmeasured Confounding

Several unmeasured confounders could bias our estimates in different directions. **Fertility intentions** may introduce positive confounding, as women who desire birth spacing may be more likely to seek digital health information and to use contraception, potentially biasing results toward an apparent association even if the true effect of digital access is null; our null findings therefore suggest that this confounding is either limited or offset by biases in opposing directions. **Recent family planning counseling exposure** may result in negative confounding, since women who receive facility-based counseling may adopt contraception regardless of digital connectivity, which could mask a true positive association between digital access and contraceptive use among women not reached by services; such bias would be expected to attenuate associations, consistent with the observed null results. **Unmet contraceptive need and active information-seeking** present an uncertain direction of bias, as women with unmet need may actively seek both digital information and services, creating positive correlation, but unmet need may also reflect structural or interpersonal barriers that digital information alone cannot overcome. Finally, **partner communication and support** represent complex confounding, as

supportive partners may facilitate both access to household technology and joint contraceptive decision-making, with the net direction of bias depending on whether partner support for technology aligns with support for family planning.

The net direction of bias from these unmeasured factors cannot be determined from available data. Our null findings could reflect either (a) truly no association between digital connectivity and contraceptive use, or (b) unmeasured confounding masking a true relationship. However, the consistency of null findings across unadjusted and adjusted models, multiple sensitivity analyses, and individual component analyses suggests the former interpretation is more plausible.

Here's the revised Section 4.6 with the AOR correction and improved formatting:

Theoretical Frameworks for Understanding Digital Health and Contraceptive Behavior

Our null findings can be understood through three complementary theoretical frameworks that explain when and why digital health interventions succeed or fail to influence behavior.

Technology Acceptance Model (TAM)

The Technology Acceptance Model posits that technology use depends on perceived usefulness and ease of use (Davis, 1989). Applied to digital family planning information, our findings suggest that while women may have access to digital platforms (ease of use achieved through widespread connectivity), they may not perceive digital health information as useful for their contraceptive decisions compared to traditional sources like healthcare providers, family members, or peers.

Several factors could limit perceived usefulness in the Cambodian context: (1) digital health information may not address women's specific concerns (e.g., managing side effects, partner negotiation, confidentiality); (2) information in Khmer language may be limited or of lower quality than English content; (3) women may lack confidence distinguishing credible from non-credible online sources; (4) culturally-specific concerns (e.g., effects on fertility, traditional medicine interactions) may be inadequately addressed in digital content.

The TAM framework helps explain why experimental digital FP interventions succeed where general connectivity shows no association: purposefully-designed interventions actively enhance perceived usefulness through tailored, interactive, culturally-relevant content and directly address ease-of-use through user-friendly interfaces and multi-channel support (Pickard et al., 2018).

Health Belief Model Application to Digital Information

As noted in our pathways discussion, the Health Belief Model emphasizes that health behavior change requires: perceived susceptibility to the health threat, perceived severity, perceived benefits exceeding barriers, and self-efficacy to take action (Rosenstock, 1974). Digital connectivity may provide information that shapes perceptions of pregnancy risk and contraceptive benefits, but passive information exposure typically fails to address three critical HBM components:

Perceived barriers: Women may learn about methods digitally but encounter information-heavy discussions of side effects without contextualization or management strategies, actually increasing perceived barriers rather than providing solutions. Without interactive support or counseling, digital information may raise concerns without building confidence to overcome them.

Self-efficacy: Adopting and continuing contraceptive methods requires confidence in one's ability to use them correctly, manage side effects, communicate with partners, and navigate healthcare systems. Static digital information rarely builds these competencies compared to interactive counseling, skills-building activities, or peer support—features present in effective digital interventions but absent from general connectivity.

Cues to action: Behavioral prompts, reminders, and motivational messages strategically timed to decision points facilitate behavior change. General internet use or phone ownership provides no such cues unless women encounter specifically-designed prompts through apps, SMS programs, or targeted campaigns.

The HBM therefore clarifies why connectivity without purposeful intervention design shows no association: it may increase knowledge (perceived susceptibility, benefits) but fails to address barriers, build self-efficacy, or provide actionable cues—mechanisms that effective digital FP programs deliberately incorporate.

Social Ecological Model and Multi-Level Determinants

The Social Ecological Model (SEM) positions health behaviors as determined by factors across five levels: individual, interpersonal, organizational, community, and policy (McLeroy et al., 1988). Digital connectivity operates primarily at the individual level (information access, knowledge), but contraceptive adoption is shaped powerfully by factors at other ecological levels that digital access alone cannot address:

Interpersonal: Partner preferences, couple communication, family influence, peer norms. The dominant effect of marital status (AOR=3.98) in our analysis reflects these interpersonal dynamics. Digital information to individual women cannot modify partner attitudes or family pressures unless interventions deliberately engage these stakeholders.

Organizational: Health service quality, provider training, facility accessibility, method availability. Digital platforms cannot remedy stockouts, provider bias, or inconvenient clinic hours that prevent contraceptive access regardless of information levels.

Community: Social norms around contraception, gender roles, cultural beliefs about fertility and family size. General digital connectivity does not challenge community-level norms, whereas community-based interventions (like Cambodia's successful rural FP programs) actively work to shift normative environments.

Policy: National family planning policies, subsidies, regulatory frameworks. While digital advocacy could theoretically influence policy, individual connectivity shows no such pathway.

The SEM framework explains why our multivariable analysis shows traditional demographic and structural factors (marital status, residence, wealth) predict contraceptive use more strongly than digital connectivity: these variables capture interpersonal, community, and structural determinants that operate at ecological levels beyond individual information access. Effective digital interventions succeed by deliberately linking individual-level engagement to interpersonal support (e.g., couple communication modules), organizational systems (e.g., service linkage, provider messaging), and community resources (e.g., peer networks)—connections not inherent in general connectivity.

Integrated Framework Implications

Together, these frameworks suggest that digital family planning interventions should be designed to: (1) enhance perceived usefulness through culturally-relevant, needs-based content addressing women's actual concerns (TAM); (2) systematically address barriers, build self-efficacy through interactive features, and provide behavioral cues to action (HBM); and (3) engage multiple ecological levels by involving partners, linking to services, and addressing community norms, not just providing information to individuals (SEM).

Our null findings align with theoretical predictions: passive connectivity provides information access (one necessary component) but fails to activate the multiple mechanisms these frameworks identify as required for behavior change. This theoretical grounding strengthens the empirical evidence base arguing for substantial investment in intervention design, implementation quality, and multi-level engagement rather than assuming infrastructure expansion drives contraceptive uptake.

Implications for Policy and Practice: Designing Effective Digital Family Planning Interventions

Our findings carry important implications for how family planning programs should approach digital health investments. Rather than assuming digital infrastructure expansion will improve contraceptive uptake, programs must strategically design interventions that address the multiple barriers between access and action. The following five principles provide a framework for evidence-informed digital family planning investment:

Principle 1: Prioritize Content Quality, Behavioral Design, and User Experience Over Infrastructure

Infrastructure investment alone is insufficient. Programs should allocate resources to four interconnected components:

Evidence-based content development:

- Comprehensive, balanced information on method options, effectiveness, side effects, and management strategies
- Content addressing culturally-specific concerns (effects on fertility, traditional medicine interactions, religious considerations)
- Clear guidance on local service access points, costs, and what to expect during clinical visits
- Authentic testimonials and case studies from women with similar backgrounds and experiences

Digital health literacy support:

- Training women to evaluate source credibility and identify misinformation
- Simple frameworks for distinguishing marketing from educational content
- Visual literacy tools for interpreting health information graphics and statistics
- Skills-building in formulating health questions and finding reliable resources

User experience optimization:

- Content in Khmer language at appropriate literacy levels, with audio/visual formats for users with limited reading proficiency
- Mobile-optimized design for low-bandwidth contexts and basic smartphones
- Navigation supporting diverse information-seeking patterns (browsing versus targeted searching)
- Accessibility features for users with disabilities

Behavioral design features:

- Interactive decision aids helping women identify methods matching their preferences and circumstances
- Side effect management tools with troubleshooting guidance and when-to-see-care criteria
- Partner communication modules with conversation starters and negotiation strategies
- Goal-setting and action-planning tools to bridge intention-behavior gaps
- Reminder systems for appointments, refills, and method-specific adherence needs

Principle 2: Address Information Ecosystems, Not Just Information Provision

Effective digital interventions move beyond one-directional information dissemination to actively shape the information environment:

Two-way communication:

- Chatbots or counselor-supported messaging enabling women to ask specific questions
- Follow-up after information access to assess comprehension and address emerging concerns
- Feedback mechanisms allowing users to report problems with content quality or relevance

Misinformation countermeasures:

- Proactive monitoring of prevalent contraceptive myths in Cambodian digital spaces
- Targeted responses to common misconceptions on social media platforms
- Partnerships with digital platforms to promote high-quality content in search results and algorithmic recommendations
- Transparent sourcing and regular updates to maintain credibility and trust

Trust-building approaches:

- Clear attribution to credible health authorities (Ministry of Health, WHO, professional associations)
- Healthcare provider endorsements and direct involvement in content creation
- Integration with established trusted channels (community health worker programs, established NGOs)
- User reviews and ratings to build social proof and community trust

Community engagement:

- Digital peer support groups or forums moderated by trained facilitators
- Storytelling platforms where women share contraceptive experiences (carefully managed to balance authenticity with accuracy)
- Influencer partnerships with locally-trusted voices to disseminate accurate information
- Social media campaigns addressing stigma and normalizing family planning discussions

Principle 3: Integrate Digital and Traditional Approaches Across the Care Pathway

Digital channels should complement rather than replace face-to-face services and community-based approaches. Integration strategies include:

Service linkage:

- Direct appointment scheduling through digital platforms
- Automated referral systems connecting women to nearby clinics with their preferred methods in stock
- Appointment reminders with options to confirm or reschedule
- Post-visit follow-up to assess satisfaction and address emerging problems

Blended care models:

- Digital information access preparing women for in-person counseling visits (improving efficiency and question quality)
- Provider-prescribed digital resources for continued learning and self-management support between visits
- Hybrid models where initial information-gathering occurs digitally, followed by human counselor support for personalized guidance
- Digital tools enhancing community health worker capacity to answer questions and provide follow-up

Multi-channel communication strategies:

- Coordinated messaging across digital, mass media, community events, and facility-based touchpoints
- Consistent core messages and branding while adapting format to channel strengths
- Recognition that different audiences prefer different channels (youth may engage digitally; older adults may prefer radio or community health workers)

Equity considerations:

- Ensuring digitally-excluded populations (rural areas without connectivity, older women, those with limited literacy or digital skills) continue receiving robust services through traditional channels
- Monitoring whether digital programs inadvertently shift resources away from proven community-based approaches serving marginalized groups
- Designing digital tools that enhance rather than replace community health workers' and providers' face-to-face interactions

Principle 4: Target Interventions to Populations and Contexts Where Digital Approaches Add Value

Strategic targeting maximizes digital health impact by focusing on populations and contexts where digital approaches offer genuine advantages:

High-potential target populations:

- Young women seeking confidential information before or outside clinical visits, who may face stigma accessing facility-based services
- Women in remote areas with limited healthcare facility access but mobile coverage
- Postpartum women needing side effect management support or counseling about switching methods
- Women experiencing method-related concerns between healthcare visits
- Couples interested in joint learning and decision-making about family planning

Favorable contexts:

- Urban/peri-urban areas with high smartphone penetration and digital literacy
- Settings where privacy and anonymity concerns make digital access preferable to facility visits
- Populations with established patterns of health information-seeking online

- Healthcare systems where digital approaches can efficiently supplement overstretched services

When to avoid digital-first approaches:

- Populations with limited digital access or literacy where community health workers or facility services show better reach
- Clinical situations requiring physical examination, method provision, or hands-on counseling (IUD insertion, injectable administration)
- Crisis situations or serious side effects requiring immediate clinical care

Principle 5: Commit to Rigorous Evaluation and Iterative Improvement

Given that general connectivity shows no association with contraceptive use, any digital family planning investment must demonstrate added value through evidence:

Implementation research priorities:

- Controlled trials or quasi-experimental designs comparing digital interventions to usual care
- Process evaluation documenting reach, engagement, and implementation fidelity alongside outcome measurement
- Cost-effectiveness analyses assessing whether digital programs achieve better outcomes per dollar than traditional approaches
- Equity analyses examining whether digital programs reduce or exacerbate disparities by education, wealth, residence, and age

User experience research:

- Qualitative studies exploring how target populations actually use digital family planning resources
- Usability testing identifying barriers to navigation, comprehension, and trust
- Focus groups examining differential engagement patterns
- Longitudinal interviews tracking digital information use across contraceptive decision-making trajectories

Adaptive learning systems:

- Analytics tracking which content women access, where they disengage, and what questions they ask
- Rapid iteration cycles testing modified content, formats, and features
- A/B testing of alternative approaches to messaging, design, and behavioral prompts
- Community feedback mechanisms informing continuous improvement

Summary: Evidence-Informed Investment in Digital Family Planning

The absence of association between general digital connectivity and contraceptive use demonstrates that technology access alone does not drive behavior change. However, this null finding should not discourage digital health investment—rather, it clarifies where investment must focus. Effective digital family planning programs require substantial investment in content quality, behavioral design, user experience, health service integration, strategic targeting, misinformation countermeasures, digital health literacy support, and rigorous evaluation.

Programs must move beyond assumptions that "if we build it, they will come" toward evidence-based intervention design grounded in behavioral theory, informed by user research, tested through controlled evaluation, and implemented with attention to equity. Digital approaches show greatest promise as one component of comprehensive, multi-channel family planning programs rather than standalone solutions—complementing and enhancing proven traditional approaches rather than replacing them. The pathway from digital access to contraceptive adoption requires intentional design, quality content, supportive ecosystems, service integration, and sustained attention to user needs and contextual realities.

Limitations

Several significant limitations should be considered when interpreting these findings. First, the cross-sectional design prevents establishing temporal ordering: we cannot determine whether digital connectivity preceded contraceptive adoption, whether contraceptive users later sought digital information (reverse causation), or whether shared underlying factors shape both; longitudinal data would be needed to track changes in connectivity and contraceptive behaviors over time and clarify these sequences. Relatedly, the study cannot support causal inference, because observed associations may reflect unmeasured confounding rather than effects of digital connectivity, and stronger designs (experimental or quasi-experimental) would be required to estimate causality.

Second, there are measurement limitations: the Digital Connectivity Index essentially captures access (e.g., phone ownership and internet use) as potential channels for information, but does not document actual exposure to family planning content, engagement frequency, purpose of use, or information quality; binary indicators also do not reflect intensity of use. Most critically, the DHS lacks measures of digital health literacy—the competencies to find, evaluate, and apply online health information. As discussed in Section 4.3, digital health literacy likely moderates whether connectivity translates to contraceptive behavior. The heterogeneity in digital health literacy across the population may explain our null findings: benefits of connectivity among digitally-literate women may be offset by lack of benefit (or even confusion and misinformation exposure) among those with low literacy, resulting in no net association at the population level. Future research incorporating validated digital health literacy assessments (such as the eHealth Literacy Scale) alongside connectivity measures would test this moderation hypothesis and identify populations requiring both connectivity infrastructure and digital skills training. In addition, self-reported variables may be affected by recall and social desirability bias, and the FP SMS exposure measure (v384d) may reflect program targeting and outreach rather than individual information-seeking.

Third, there are sample and outcome constraints: including all women aged 15–49 regardless of pregnancy risk (e.g., never sexually active, abstinent, pregnant, postpartum amenorrheic, infecund) introduces heterogeneity in contraceptive need that may attenuate associations and may help explain why parity shows little effect in this analysis; future work should examine whether relationships differ by pregnancy risk status. The outcome measure—current use of any modern method—also collapses diverse methods with different adoption pathways, side-effect concerns, and information needs, and very small numbers of sexually active unmarried women limit stable subgroup analyses.

Finally, unmeasured confounding remains plausible (e.g., fertility intentions, partner preferences and communication, recent service contact and counseling, prior contraceptive experience, perceived need, the quality and trustworthiness of digital information encountered, and peer/social network influences). Overall, the findings are context-specific to Cambodia in 2021–22, and the rapidly evolving digital environment and family planning programs mean patterns may differ across time and in settings with different levels of digital penetration, program maturity, or cultural norms around contraception and technology use.

CONCLUSION

This study found no association between digital connectivity and modern contraceptive use among women aged 15–49 in Cambodia after accounting for sociodemographic and reproductive factors. Marital status (reflecting pregnancy risk) and rural residence remain the dominant correlates of contraceptive behavior in this population. These findings suggest that digital media access alone is not associated with contraceptive uptake, highlighting

the importance of content quality, purposeful intervention design, and integration with comprehensive family planning services.

The null findings have important implications: they challenge assumptions that digital expansion automatically improves health behaviors, while reinforcing that traditional determinants—pregnancy risk, service access, and reproductive context—remain primary drivers of contraceptive use. Digital health strategies should move beyond expanding access toward developing evidence-based, culturally appropriate, and user-centered digital content and services.

Digital family planning programs should prioritize evidence-based content, interactive behavior-change mechanisms, integration with traditional service delivery, and attention to equity and quality, rather than assuming that technology access alone will improve outcomes. Such approaches, combined with continued strengthening of facility-based services, community health workers, and reduction of structural barriers, offer the most significant promise for improving reproductive health outcomes in Cambodia's increasingly digital society.

Future research should address several key priorities:

Methodological improvements:

- Employ longitudinal designs to examine temporal relationships and establish causal pathways
- Measure exposure to specific family planning digital content rather than general digital access
- Include validated digital health literacy scales (such as the eHealth Literacy Scale) to assess competencies in finding, evaluating, and applying online health information
- Conduct analyses stratified by pregnancy risk status (married/sexually active women) to assess whether associations differ among women at immediate pregnancy risk

Distinguishing digital access dimensions:

- Differentiate between smartphone ownership versus basic phone ownership (smartphones enable richer multimedia content, app use, and interactive features)
- Measure frequency and intensity of internet use (daily versus occasional users; data-heavy versus light usage patterns)
- Assess social media engagement specifically, as health information often circulates through peer networks on these platforms
- Distinguish use of health-specific apps or websites from general internet activity
- Document self-reported use of digital resources specifically for health information-seeking versus other purposes (entertainment, communication, business)
- Examine platform-specific dynamics (Facebook, messaging apps, search engines) which have distinct information ecosystems and user engagement patterns

Qualitative research to understand mechanisms:

Mixed-methods designs combining quantitative analysis with qualitative depth are essential for understanding the pathways between digital connectivity and contraceptive behavior. In-depth interviews and focus groups with Cambodian women across the digital connectivity spectrum would provide critical insights into: (1) how women actually use digital technologies for reproductive health decisions; (2) what types of family planning information they encounter online and how they evaluate credibility; (3) what specific barriers prevent digital

information from translating to contraceptive adoption, including misinformation exposure, gender norms constraining autonomy, partner opposition, service access barriers, and trust concerns; (4) how partner dynamics and couple communication influence digital information-seeking and contraceptive decision-making; and (5) what specific digital intervention features (interactive tools, personalized content, counselor support) would meaningfully support their family planning needs. Such qualitative evidence would empirically test the hypothesized pathways proposed in this discussion and inform culturally-appropriate digital intervention design for the Cambodian context.

Experimental evaluation:

- Conduct randomized controlled trials of targeted digital interventions with embedded behavior change mechanisms to establish causal effects
- Include process evaluations documenting reach, engagement, implementation fidelity, and user experience alongside outcome measurement
- Perform cost-effectiveness analyses comparing digital programs to traditional service delivery approaches
- Conduct equity analyses examining whether digital interventions reduce or exacerbate disparities by education, wealth, residence, age, and marital status

The absence of association between general digital connectivity and contraceptive use observed in this study establishes an important baseline for digital family planning research. Future interventions must demonstrate added value beyond this null baseline, with recognition that access does not equal exposure, exposure does not equal engagement, and engagement does not automatically translate to behavior change. Effective digital interventions likely succeed through mechanisms not captured by connectivity measures alone: behavioral targeting, personalized messaging, interactive decision support, integration with health services, and systematic attention to content quality, digital health literacy, and user needs.

Declarations

Conflict of Interest

The authors declare that they have **no conflicts of interest**. This research was conducted independently and received **no external financial support**.

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No funding was received for this study.

Data Availability Statement

The data used in this study come from the **2021-22 Cambodia Demographic and Health Survey (CDHS)**. These datasets are publicly available from the DHS Program website upon registration and approval: <https://www.dhsprogram.com/data/available-datasets.cfm>

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Author Contributions

- **Yem Sokha:** Conceptualization, study design, data management, statistical analysis, interpretation of findings, and manuscript drafting and revision.
- **Mike Renfrew:** Methodological guidance, interpretation of results, and critical manuscript revision.
- **Tun Sreypeov:** Data analysis support and manuscript review.
- **Tineke Water:** Conceptualization, study design oversight, interpretation of findings, and critical manuscript revision.

AI Declaration

The authors declare that generative artificial intelligence (AI) tools (including ChatGPT) were used to assist with language editing, clarification of scientific writing, and organization of the manuscript text. AI was not used to generate data, perform statistical analyses, interpret results, or make substantive scientific decisions. All analyses, interpretations, and final content were reviewed, verified, and approved by the authors, who take full responsibility for the integrity and accuracy of the work.

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Tables and Figures

Figure 1. Conceptual Framework

MEASURED CONFOUNDERS:

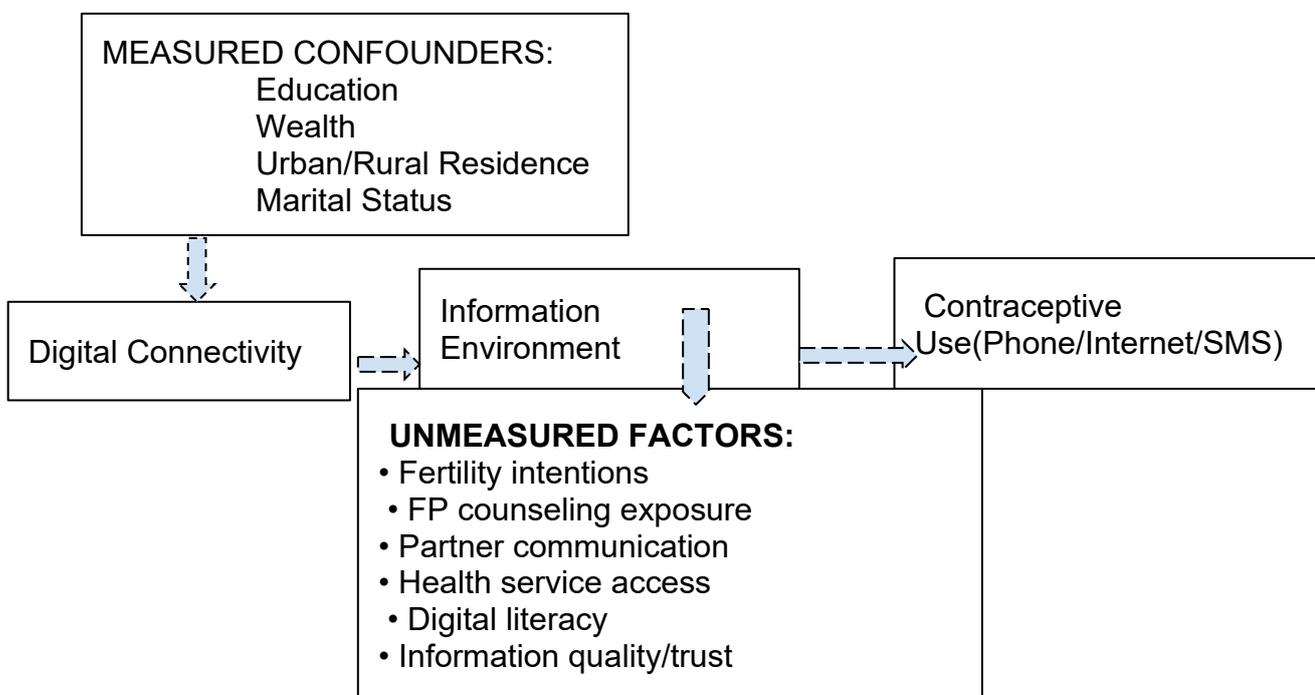


Figure 1. Simplified conceptual model showing hypothesized relationships between digital connectivity and modern contraceptive use. Solid arrows indicate measured associations tested in this study. Dashed arrows with "?" indicate uncertain pathways: we cannot determine whether digital connectivity influences contraceptive use, whether contraceptive users seek digital information (reverse causation), or whether unmeasured factors drive both. Cross-sectional data prevent establishing temporal ordering or causal direction.

Table 2. Distribution of Modern Contraceptive Use by Sociodemographic Characteristics among Women Aged 15-49 (N=34,402)

Characteristic	Category	Modern Method Use (%)	No Modern Method (%)	Total (%)	p-value
Overall		45.7	54.3	100.0	
Age group	15-24 years	45.4	54.6	100.0	0.0003
	25-34 years	48.8	51.2	100.0	
	35-49 years	44.1	55.9	100.0	
Education	No education	45.7	54.3	100.0	0.992
	Primary	45.8	54.2	100.0	
	Secondary	45.4	54.6	100.0	
	Higher	45.4	54.6	100.0	
Wealth quintile	Poorest	48.4	51.6	100.0	0.125
	Poorer	45.0	55.0	100.0	
	Middle	43.4	56.6	100.0	
	Richer	44.9	55.1	100.0	
	Richest	46.5	53.5	100.0	
Residence	Urban	45.4	54.6	100.0	0.603
	Rural	45.4	54.6	100.0	

Note: All estimates are survey-weighted. P-values from design-based F-tests accounting for complex survey design.

Table 3. Digital Connectivity Index and Modern Contraceptive Use among Women Aged 15-49 (N=34,402)

Digital Connectivity Level	N	% of Sample	Modern Method Use (%)	No Modern Method (%)
0 (No channels)	6,882	20.0	45.0	55.0
1 (One channel)	8,129	23.6	45.8	54.2
2 (Two channels)	16,447	47.8	45.4	54.6
3 (Three channels)	2,944	8.6	48.3	51.7
Total	34,402	100.0	45.7	54.3

Note: All estimates are survey-weighted. P-value from design-based F-test: $F(2.95, 1946.84) = 0.61$, $p = 0.603$. No significant association between digital connectivity levels and contraceptive use.

Table 4. Logistic Regression Models: Association Between Digital Connectivity and Modern Contraceptive Use among Women Aged 15-49 (N=34,402)

Variable	Model 0 (Unadjusted)	Model 1 (Age + Education)	Model 2 (Fully Adjusted)
	OR (95% CI)	OR (95% CI)	AOR (95% CI)
Digital Connectivity Index	1.02 (0.97-1.09)	1.02 (0.96-1.08)	1.05 (0.99-1.12)
	$p=0.437$	$p=0.613$	$p=0.133$
Age group (ref: 15-24)			
25-34 years	—	1.15 (0.99-1.33)	1.15 (0.99-1.33)
		$p=0.076$	$p=0.076$
35-49 years	—	0.94 (0.81-1.09)	0.94 (0.80-1.09)
		$p=0.386$	$p=0.386$

Education (ref: no education)			
Primary	—	0.98 (0.85-1.14)	0.99 (0.85-1.16)
		<i>p=0.812</i>	<i>p=0.913</i>
Secondary	—	0.92 (0.77-1.11)	0.92 (0.76-1.10)
		<i>p=0.343</i>	<i>p=0.359</i>
Higher	—	0.87 (0.63-1.21)	0.85 (0.61-1.18)
		<i>p=0.416</i>	<i>p=0.340</i>
Wealth quintile (ref: poorest)			
Poorer	—	—	0.88 (0.75-1.03)
			<i>p=0.121</i>
Middle	—	—	0.85 (0.73-0.99)
			<i>p=0.035</i>
Richer	—	—	0.97 (0.80-1.17)
			<i>p=0.738</i>
Richest	—	—	1.05 (0.86-1.28)
			<i>p=0.632</i>
Residence (ref: urban)			
Rural	—	—	1.20 (1.04-1.39)
			<i>p=0.013</i>

Marital status (ref: never married)			
Currently married/cohabiting	—	—	3.98 (1.65-9.61)
			<i>p=0.002</i>
Formerly married	—	—	0.19 (0.07-0.55)
			<i>p=0.002</i>
Parity (per child)	—	—	1.01 (0.96-1.06)
			<i>p=0.693</i>

Note: OR = Odds Ratio; AOR = Adjusted Odds Ratio; CI = Confidence Interval. Bold text indicates statistical significance at $p < 0.05$. All models account for complex survey design with sampling weights, clustering, and stratification.

Table S1. Sensitivity Analysis: Individual Digital Connectivity Components (Fully Adjusted Models)

Component	Adjusted OR (95% CI)	p-value
Mobile phone ownership	1.02 (0.94-1.11)	0.621
Internet use (any vs. never)	0.98 (0.91-1.06)	0.584
FP SMS exposure	1.08 (0.94-1.24)	0.287

Note: Each component entered separately in models adjusted for age, education, wealth, residence, marital status, and parity. Survey-weighted estimates accounting for complex design. None of the individual components show significant associations with modern contraceptive use.

Interpretation: The consistent null associations across all three components examined separately support the robustness of our main findings to index construction decisions. Results do not depend on treating connectivity as a composite index versus examining channels individually.

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