



Smart Prenatal Care Systems and the Future of Obstetric Healthcare

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Abstract

This study examines the implementation of smart prenatal care systems in maternal healthcare services in Amazonas, Brazil, with particular attention to tele-obstetrics, digital prenatal monitoring, and healthcare accessibility in geographically isolated communities. The research aims to analyze how digital healthcare innovation contributes to improving obstetric services while simultaneously identifying structural and institutional barriers affecting implementation effectiveness. A qualitative case study approach was employed through semi-structured interviews, field observations, and document analysis involving healthcare professionals, pregnant women, healthcare administrators, and policymakers in Manaus and surrounding riverine communities. The findings indicate that smart prenatal care systems significantly improved communication between healthcare providers and pregnant women, strengthened early detection of pregnancy risks, and enhanced healthcare coordination in remote regions. Infrastructural inequality, unstable internet connectivity, limited digital literacy, and shortages of healthcare personnel remained major constraints affecting service effectiveness. The study contributes to discussions on digital health governance, healthcare equity, and maternal healthcare transformation in developing regions while emphasizing the importance of inclusive infrastructural and institutional development for sustainable tele-obstetric implementation.

INTRODUCTION

Maternal healthcare has become one of the most critical global public health priorities in the twenty-first century, particularly in developing and middle-income countries experiencing persistent inequalities in access to obstetric services. Despite substantial advances in medical technology and prenatal monitoring, maternal mortality, high-risk pregnancy complications, and disparities in antenatal healthcare delivery continue to challenge healthcare systems worldwide. The integration of digital technologies into obstetric services has emerged as a transformative strategy to improve maternal health outcomes, especially through smart prenatal care systems that utilize telemedicine, artificial intelligence (AI), remote monitoring, and mobile health applications (Bayomi et al., 2025; El Arab et al., 2025; Silva et al.,

2024). These technological innovations are increasingly viewed as effective mechanisms for enhancing early detection of pregnancy complications, increasing healthcare accessibility, and strengthening communication between pregnant women and healthcare professionals (Botutihe et al., 2025; Wijayanti & Indriani, 2025; Tahira & Fatima, 2024; Obeagu & Obeagu, 2024; Al-Worafi, 2024; Aidoo, 2025).

In recent years, smart prenatal care systems have gained considerable attention due to their potential to address structural limitations in healthcare accessibility, particularly in geographically isolated and socioeconomically vulnerable areas (Batoool & Lopez, 2023; Sánchez-Mateos & Pulpón, 2025; Chowdhury & Ravi, 2022). Studies have demonstrated that digital maternal healthcare platforms can significantly improve prenatal monitoring efficiency, reduce delays in obstetric intervention, and increase patient adherence to antenatal care schedules. Furthermore, AI-assisted obstetric screening and telehealth-based prenatal consultations have shown promising results in reducing maternal and neonatal risks through real-time health monitoring and predictive analytics (Wang et al., 2025; Nazari et al., 2025; Mohamed et al., 2025; Mehta et al., 2025). However, the implementation of digital obstetric systems remains uneven across regions, particularly in countries characterized by substantial territorial disparities and unequal healthcare infrastructure (Cheshmehzangi & Zou, 2025; Duque et al., 2023; Mishra et al., 2023).

One of the countries facing these challenges is Brazil, where maternal healthcare inequalities remain a persistent issue despite the existence of a universal healthcare system under the Sistema Único de Saúde (SUS). The disparities are particularly evident in the Amazon region, where limited healthcare infrastructure, geographic isolation, and socioeconomic vulnerability significantly affect maternal healthcare accessibility (Agbeve et al., 2025; Jaramillo Lizana, 2024; Fausto et al., 2022; Pinho Neto et al., 2024). In the state of Amazonas, especially in the municipality of Manaus and surrounding rural riverine communities, pregnant women frequently encounter barriers in obtaining adequate prenatal care due to transportation difficulties, shortages of obstetric specialists, and delayed emergency responses. These conditions contribute to elevated risks of maternal complications, preventable pregnancy-related morbidity, and unequal healthcare outcomes.

The emergence of digital healthcare innovations in Brazil has encouraged policymakers and healthcare institutions to explore tele-obstetrics and smart prenatal monitoring systems as alternative solutions to maternal healthcare disparities. Several governmental and institutional initiatives have attempted to integrate telemedicine into primary healthcare services, including maternal and reproductive health programs in remote regions. During and after the COVID-19 pandemic, the acceleration of digital health adoption further highlighted the strategic importance of telehealth in ensuring continuity of prenatal care. In Amazonas, mobile-based prenatal consultation systems and remote obstetric monitoring initiatives have started to gain institutional attention as mechanisms to reduce healthcare inequalities among vulnerable maternal populations (Ssegujja et al., 2025; Al Dahdah, 2022; Nyatuka et al., 2026; Shanmuga Sundari, 2026).

Previous studies have extensively examined the role of telemedicine in improving healthcare accessibility and maternal health outcomes. Research by Endehabtu et al. (2024) emphasized that digital maternal health interventions can strengthen continuity of prenatal care and improve communication between healthcare providers and pregnant women. Similarly, Monaghesh and Hajizadeh (2020) argued that telehealth systems became increasingly effective during public health emergencies by minimizing healthcare disruptions and supporting remote medical consultations. In the context of Latin America, studies have also indicated that digital

healthcare technologies possess considerable potential to address regional inequalities in healthcare delivery. However, most existing studies remain predominantly focused on technological adoption, healthcare efficiency, or patient satisfaction without sufficiently examining the broader structural dimensions of healthcare inequality in remote obstetric services (Capasso et al., 2024; Hinton et al., 2024; Hod et al., 2023; Monaghesh & Hajizadeh, 2020).

Furthermore, the previous work on smart prenatal care systems in Brazil focuses mainly on urban health care environments such as São Paulo, Rio de Janeiro, and other metropolitan cities with a more developed health care sector. There is little academic literature on the subject of tele-obstetric services in remote regions in the Brazilian Amazon where infrastructural, digital and territorial conditions pose particular challenges. The current literature also tends to focus on quantitative or technological approaches, and does not consider the socio-institutional and governance aspects that might impact the performance of digital obstetric healthcare systems. However, there is limited awareness on how smart prenatal care systems work together with local healthcare capacity, institutional readiness and inequalities in maternal health services in geographically isolated communities (Chianumba et al., 2023; Grobbelaar & Uriona-Maldonado, 2019).

This work aims to overcome these limitations by exploring the implementation of smart prenatal care systems in maternal health services in Manaus city and in certain Amazon rural communities of the state of Amazonas, Brazil. This research is unique because it examines the nexus of digital innovation, healthcare access, and obstetric inequity in healthcare environments outside of cities, as opposed to other existing studies that have looked into technological performance or urban healthcare systems. The study examines the role of tele-obstetrics and the use of digital prenatal monitoring systems for improving maternal health care access and the structural and institutional barriers to their use (Balcioglu, 2026; Camille, 2024).

The novelty of this research is the integrative perspective that brings together the analysis of digital health innovation and the socio-spatial dimensions of maternal health inequality in the Brazilian Amazon region. This study adds to the body of knowledge in the field of maternal health by offering empirical data from an under-researched obstetric healthcare environment, which is remote from hospital. Moreover, the study provides a contextual understanding of the effective use of smart prenatal care systems as policy tools to improve the maternal health service delivery system in under-served areas, rather than just as technologies. The goal of this paper is to examine the role, effectiveness and challenges of smart prenatal care systems in improving obstetric health care services in Amazonas, Brazil, and to help enhance the debate on digital health governance, health care equity and sustainable health care innovation in developing regions.

METHODS

Research Design

This study employed a qualitative research design with a case study approach to examine the implementation of smart prenatal care systems in obstetric healthcare services in Amazonas, Brazil. A qualitative approach was considered appropriate because the research aimed to explore institutional practices, healthcare experiences, and structural challenges associated with digital maternal healthcare implementation in geographically isolated regions. According to Robert K. Yin, case study research enables an in-depth understanding of contemporary phenomena within real-life contexts, particularly when contextual conditions are highly relevant to the phenomenon being investigated. This approach allowed the researchers to analyze the interaction between digital healthcare innovation, institutional readiness, and maternal healthcare inequalities in remote obstetric services.

The study specifically focused on tele-obstetrics and smart prenatal monitoring initiatives implemented within public healthcare facilities under the Brazilian Unified Health System (Sistema Único de Saúde/SUS). The research emphasized how digital technologies were utilized to improve healthcare accessibility for pregnant women living in vulnerable and remote communities.

Research Location and Context

The research was conducted in Manaus and several surrounding rural riverine communities in the state of Amazonas, Brazil. These locations were selected due to their strategic relevance to maternal healthcare inequality and digital healthcare implementation in remote regions. Manaus functions as the primary healthcare referral center in Amazonas, while many rural communities remain geographically isolated and dependent on limited healthcare infrastructure. Transportation barriers, shortage of obstetric specialists, and restricted access to emergency maternal healthcare services create substantial challenges for prenatal care delivery in these areas. The selection of Amazonas as the research setting was also based on the increasing governmental attention toward telemedicine and digital healthcare integration following the COVID-19 pandemic. Several public healthcare institutions in the region have initiated telehealth-based maternal healthcare services aimed at strengthening prenatal monitoring and reducing delays in obstetric intervention.

Data Collection Techniques

Data were collected between January and March 2026 through semi-structured interviews, field observations, and document analysis. Semi-structured interviews were used to obtain in-depth information regarding healthcare experiences, institutional implementation processes, and perceived challenges in smart prenatal care systems. This interview model enabled flexibility in exploring participants' perspectives while maintaining consistency with the research objectives. Field observations were conducted in selected healthcare facilities to examine healthcare service processes, digital infrastructure availability, and interactions between healthcare providers and patients in tele-obstetric practices. In addition, document analysis was utilized to review healthcare policy documents, institutional reports, telemedicine guidelines, and maternal healthcare statistics related to prenatal care services in Amazonas.

Informants and Sampling Technique

The informants in this study consisted of healthcare professionals, pregnant women, healthcare administrators, and local health policymakers involved in maternal healthcare services. The participants included obstetricians, midwives, nurses, telemedicine coordinators, and pregnant women who had utilized digital prenatal care services. Informants were selected using purposive sampling because the study required participants who possessed direct knowledge and experience regarding tele-obstetric implementation. To enrich the diversity of perspectives, snowball sampling was subsequently employed to identify additional participants recommended by initial informants. In total, 22 informants participated in this research. The sampling process continued until data saturation was achieved, meaning that additional interviews no longer generated substantially new information.

Data Analysis Technique

The collected data were analyzed using thematic analysis following the framework developed by Virginia Braun and Victoria Clarke. The analysis process involved data transcription, coding, categorization, and theme development. Initially, interview recordings and observation notes were transcribed and organized systematically. The researchers then identified recurring patterns related to digital healthcare accessibility, institutional barriers, healthcare inequality, and maternal healthcare

experiences. Thematic categories were subsequently interpreted to construct analytical explanations regarding the effectiveness and limitations of smart prenatal care systems in remote obstetric healthcare contexts. Data interpretation was conducted iteratively to ensure consistency between empirical findings and conceptual analysis.

Validity and Reliability

To ensure research credibility and trustworthiness, this study applied methodological triangulation by combining interviews, observations, and document analysis. Source triangulation was also employed through the inclusion of multiple participant groups with different institutional backgrounds and healthcare experiences. Furthermore, member checking was conducted by confirming several interview interpretations with selected participants to minimize researcher bias and improve interpretive accuracy. The researchers additionally maintained detailed field notes and analytical memos throughout the research process to strengthen transparency and dependability. These procedures were implemented to ensure that the findings accurately reflected the realities of digital obstetric healthcare implementation in Amazonas, Brazil.

RESULTS AND DISCUSSION

This section presents the findings derived from interviews, field observations, and document analysis regarding the implementation of smart prenatal care systems in obstetric healthcare services in Amazonas, Brazil. The findings are organized systematically to reflect the thematic categories generated during the coding and analytical processes. In addition to presenting empirical findings, this section also integrates observational evidence, institutional documentation, triangulation results, and participant narratives to strengthen analytical validity.

The analysis identified four dominant themes: (1) expansion of digital accessibility in prenatal healthcare, (2) institutional and infrastructural barriers, (3) maternal perceptions toward tele-obstetric services, and (4) digital innovation and the reduction of obstetric inequality. These themes emerged consistently across interviews, observations, and healthcare policy documents analyzed during the research process. Before discussing the thematic findings, the study first presents the characteristics of research informants and the coding structure used during data analysis.

Characteristics of Research Informants

The study involved 22 informants selected through purposive and snowball sampling techniques. The participants represented multiple institutional and social backgrounds directly related to maternal healthcare services and tele-obstetric implementation in Amazonas.

Table 1. Characteristics of Research Informants

Informant Category	Number of Participants	Institutional/Community Context
Obstetricians	4	Public hospitals in Manaus
Midwives	5	Community healthcare centers
Nurses	4	Rural maternal healthcare units
Pregnant women	6	Riverine communities in Amazonas
Healthcare administrators	2	SUS healthcare institutions
Local health policymakers	1	Regional health office

Source: Field Research Data, 2026

The distribution of participants enabled triangulation between institutional perspectives and community healthcare experiences. Interviews with pregnant women were particularly important for understanding how tele-obstetric systems affected healthcare accessibility in geographically isolated communities. Meanwhile, healthcare professionals and policymakers provided institutional insights regarding implementation capacity, operational barriers, and digital healthcare governance.

Field observations were conducted in three public healthcare facilities in Manaus and four rural healthcare units located in riverine areas surrounding Amazonas. Observations focused on digital infrastructure, telemedicine equipment, healthcare workflows, internet connectivity, and interactions between healthcare providers and patients. In addition, document analysis included regional healthcare policy documents, telemedicine implementation reports, maternal healthcare statistics from the Sistema Único de Saúde (SUS), and institutional digital healthcare guidelines issued between 2022 and 2025.

Thematic Coding and Data Saturation

Thematic analysis generated four major themes and several supporting categories. Coding was conducted iteratively using interview transcripts, observation notes, and institutional documents.

Table 2. Thematic Coding Matrix

Main Themes	Supporting Categories
Digital accessibility expansion	Remote consultation, mobile communication, prenatal monitoring
Institutional barriers	Internet instability, lack of equipment, limited personnel
Maternal healthcare perceptions	Trust, psychological reassurance, communication quality
Reduction of obstetric inequality	Referral efficiency, healthcare coordination, rural accessibility

Source: Processed Qualitative Data, 2026

The coding process reached data saturation after the twentieth interview, where no substantially new thematic patterns emerged. Additional interviews were conducted to confirm consistency across participant groups. Triangulation between interviews, observations, and institutional documents strengthened interpretive reliability and ensured consistency of findings.

Expansion of Digital Accessibility in Prenatal Healthcare Services

One of the most dominant findings concerns the increasing accessibility of prenatal healthcare services through tele-obstetric systems. Healthcare institutions in Manaus progressively integrated telemedicine technologies into maternal healthcare services to improve healthcare communication and reduce delays in prenatal consultation. Document analysis revealed that regional maternal healthcare programs in Amazonas expanded digital healthcare initiatives significantly after the COVID-19 pandemic. Institutional reports issued by regional healthcare authorities between 2022 and 2025 indicated increasing governmental investment in telemedicine platforms, remote prenatal monitoring, and mobile healthcare coordination systems.

Field observations confirmed that healthcare facilities in Manaus had established dedicated telemedicine rooms equipped with computers, digital patient records, internet-based communication systems, and online consultation platforms.

However, observational findings also showed that rural healthcare facilities possessed more limited technological capacity.

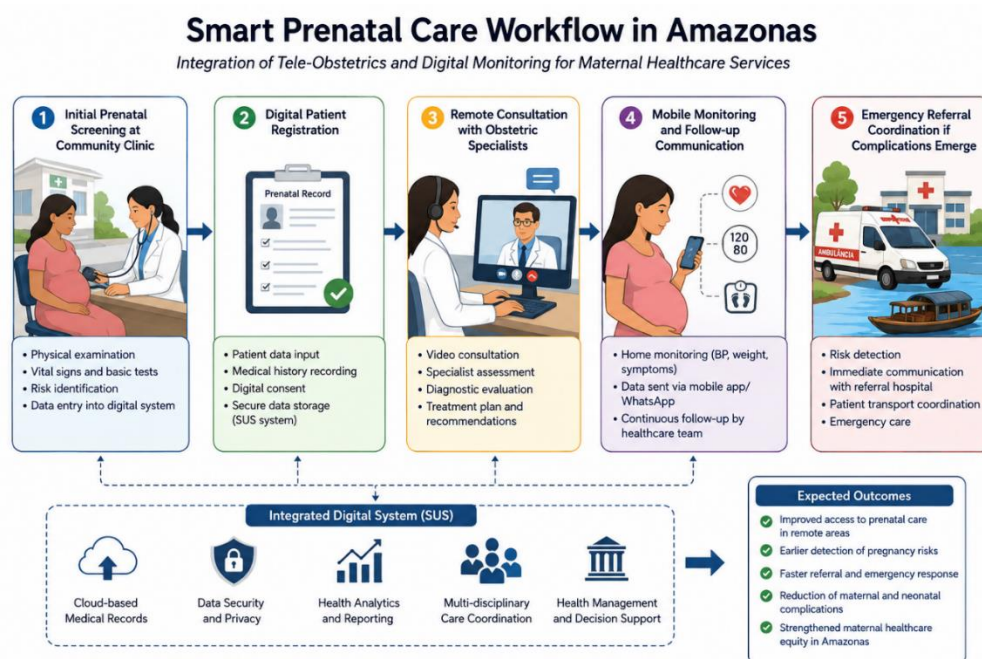


Figure 1. Smart Prenatal Care Workflow in Amazonas

Source: Observation and Institutional Documentation, 2026

Healthcare workers emphasized that mobile communication platforms became essential tools for maintaining healthcare continuity in remote areas.

An obstetric nurse explained:

“Many pregnant women live several hours away from Manaus and transportation depends heavily on river conditions. Through WhatsApp communication and telemedicine consultations, we can monitor symptoms more regularly and identify high-risk conditions earlier. Previously, many women only arrived at hospitals after complications became severe because communication with healthcare providers was extremely limited.”

This statement illustrates how digital healthcare systems function as practical mechanisms for overcoming geographic barriers in maternal healthcare services.

A telemedicine coordinator further stated:

“The pandemic accelerated digital adaptation dramatically. Before COVID-19, tele-obstetrics was discussed mostly as a pilot initiative. After the pandemic, healthcare institutions realized that remote prenatal monitoring was necessary for maintaining continuity of maternal healthcare services in isolated communities. Since then, digital consultation systems have become increasingly institutionalized.”

The interview demonstrates that public health emergencies acted as catalysts for digital healthcare transformation in Amazonas.

A pregnant woman from a riverine community also explained:

“Traveling to Manaus requires transportation costs that many families cannot afford regularly. Online communication with healthcare workers helps us receive medical advice faster. Even if internet signals are unstable sometimes, having direct contact with healthcare providers makes us feel more secure during pregnancy.”

The findings consistently indicate that tele-obstetric systems improved healthcare accessibility while simultaneously increasing emotional reassurance among pregnant women in remote communities.

Institutional and Infrastructural Barriers

Despite the positive expansion of digital healthcare accessibility, the study identified substantial structural barriers limiting the effectiveness of tele-obstetric implementation. Field observations revealed that internet instability remained one of the most significant operational constraints. Several rural healthcare facilities experienced interrupted connectivity during consultations, limiting communication quality between healthcare providers and patients.

Table 3. Main Institutional and Operational Barriers

Identified Barrier	Observational Findings
Internet instability	Interrupted consultations in rural clinics
Limited digital equipment	Insufficient computers and telemedicine devices
Shortage of specialists	Limited obstetric personnel in remote units
Low digital literacy	Difficulty operating healthcare applications
Geographic isolation	Delayed emergency referrals

Source: Observation and Interview Data, 2026

A healthcare administrator explained:

“The implementation gap between Manaus and remote healthcare units remains very visible. Some rural facilities still operate with unstable electricity and internet access. Digital healthcare systems require infrastructure readiness, but in isolated communities these conditions are still inconsistent.”

This statement demonstrates that healthcare digitalization remains strongly influenced by regional infrastructural inequality.

A midwife working in a riverine clinic further stated:

“Some patients are unfamiliar with smartphones or online communication platforms. We often need to guide them repeatedly before telemedicine consultations become effective. In emergency situations, unstable signals can create serious risks because communication delays affect medical decision-making.”

The findings suggest that digital exclusion remains interconnected with healthcare inequality.

Another obstetric specialist emphasized:

“Tele-obstetrics helps improve communication and monitoring, but it cannot replace direct examinations entirely. Complicated pregnancies still require laboratory testing, ultrasound evaluation, and emergency intervention that cannot be conducted remotely.”

This interview confirms that telemedicine functions primarily as a complementary healthcare mechanism rather than a complete replacement for conventional obstetric care.

Maternal Perceptions and Healthcare Trust

Most pregnant women interviewed expressed positive attitudes toward tele-obstetric services because digital systems reduced transportation burdens and improved communication access with healthcare workers.

One participant explained:

“Previously, we waited until the next scheduled visit even if symptoms appeared suddenly. Now we can directly contact nurses or doctors through mobile communication. This makes us feel calmer because we receive guidance faster.”

The interview reflects how telemedicine contributes not only to healthcare accessibility but also to psychological reassurance during pregnancy.

Another participant stated:

“Online consultations are useful, especially for routine monitoring. However, I still trust direct examinations more because doctors can physically examine the baby and immediately perform medical tests if necessary.”

The findings indicate that trust in telemedicine remains conditional and influenced by perceptions regarding diagnostic reliability.

A healthcare worker further noted:

“Patients generally appreciate telemedicine because it reduces travel costs and waiting time. However, trust becomes weaker when communication quality is disrupted by unstable internet or unclear explanations.”

This demonstrates that communication quality significantly influences patient acceptance of digital healthcare systems.

Digital Innovation and the Reduction of Obstetric Inequality

The final theme concerns the broader role of digital healthcare innovation in reducing maternal healthcare inequality in Amazonas. Document analysis showed that regional healthcare authorities increasingly positioned telemedicine as a strategic mechanism for improving healthcare equity in geographically isolated areas. Institutional reports emphasized that tele-obstetric systems contributed to earlier risk detection, improved referral coordination, and broader healthcare coverage.

A regional policymaker explained:

“Telemedicine is becoming a long-term healthcare strategy because geographic barriers in Amazonas cannot be eliminated completely. The objective is not only technological modernization but also expanding healthcare equity for vulnerable maternal populations.”

A maternal healthcare coordinator added:

“Digital healthcare systems have improved communication between rural clinics and referral hospitals. High-risk pregnancies can now be identified earlier and coordinated more efficiently than before.”

Another healthcare administrator emphasized:

“The benefits of tele-obstetrics are visible, but inequality still exists because communities with stronger infrastructure adapt faster than isolated villages. Sustainable investment remains necessary if digital healthcare is expected to reduce maternal disparities comprehensively.”

Triangulation between interviews, observations, and institutional documents confirms that smart prenatal care systems significantly improved healthcare accessibility and coordination in Amazonas. Nevertheless, the findings also demonstrate that digital innovation alone remains insufficient to eliminate obstetric inequality without simultaneous improvements in infrastructure, institutional readiness, and digital inclusion policies.

Digital Health Innovation, Obstetric Inequality, and the Transformation of Maternal Healthcare in Remote Regions

The findings of this study demonstrate that smart prenatal care systems have become increasingly important in transforming maternal healthcare accessibility in geographically isolated regions of Amazonas, Brazil. The integration of tele-obstetrics, mobile prenatal monitoring, and digital communication platforms has contributed to improved healthcare coordination, earlier detection of pregnancy risks, and stronger continuity of prenatal care. However, the study also reveals that the effectiveness of digital maternal healthcare remains strongly shaped by infrastructural inequality, institutional readiness, and uneven digital inclusion. These findings contribute to broader discussions regarding the role of digital health innovation in addressing healthcare disparities within developing and territorially fragmented healthcare systems.

One of the central findings concerns the expansion of digital healthcare accessibility through tele-obstetric systems. This finding aligns with previous studies emphasizing the transformative role of telemedicine in improving maternal healthcare delivery in underserved areas. Research by Michele Galle and colleagues argued that digital maternal healthcare interventions strengthen continuity of prenatal services and improve communication between healthcare providers and pregnant women. Similarly, studies conducted by Elham Monaghesh and Alireza Hajizadeh highlighted that telehealth systems became increasingly significant during and after the COVID-19 pandemic because they enabled healthcare systems to maintain service continuity amid mobility restrictions and institutional pressure. The present study reinforces these arguments by demonstrating that tele-obstetric systems in Amazonas function not only as emergency healthcare adaptations but also as long-term healthcare accessibility mechanisms in regions characterized by persistent geographic isolation.

Nevertheless, this research extends previous literature by emphasizing the socio-spatial dimensions of digital maternal healthcare implementation. Existing studies on telemedicine frequently focus on technological effectiveness, patient satisfaction, or healthcare efficiency within urban or technologically advanced healthcare environments. By contrast, this study demonstrates that digital healthcare implementation in remote regions involves complex interactions between infrastructure, geography, healthcare governance, and social inequality. In Amazonas, tele-obstetric systems are deeply influenced by river transportation dependency, unstable internet infrastructure, shortages of obstetric specialists, and unequal digital literacy among patients. Consequently, digital healthcare innovation cannot be understood solely through technological perspectives but must also be analyzed within broader structural and territorial contexts.

The findings regarding infrastructural limitations support previous research emphasizing the persistence of digital inequality in healthcare transformation. Studies conducted in developing countries have repeatedly shown that telemedicine effectiveness depends heavily on technological infrastructure and institutional capacity. In this study, unstable internet connectivity and limited digital equipment significantly constrained the operational reliability of tele-obstetric consultations in rural healthcare facilities. These findings correspond with research suggesting that digital healthcare initiatives may unintentionally reproduce existing inequalities when infrastructural disparities remain unresolved. In other words, technological innovation alone does not automatically guarantee healthcare equity (Gallifant et al., 2023; Arefin, 2024).

However, the present study also identifies an important nuance that differentiates it from earlier research. While previous studies often portray infrastructural limitations primarily as technological problems, this research demonstrates that healthcare workers and communities actively adapt digital systems to local realities through flexible communication practices. Informal platforms such as WhatsApp became

essential instruments for sustaining healthcare communication when formal telemedicine systems were less accessible. This finding suggests that technological adaptability and contextual flexibility play crucial roles in the success of digital maternal healthcare systems in resource-limited settings. Theoretically, this contributes to discussions on adaptive digital governance by emphasizing that healthcare innovation in developing regions often depends more on institutional flexibility than on technological sophistication alone (Nguar, 2022; Cheng et al., 2026; Olayiwola et al., 2026).

Another important finding concerns maternal perceptions toward tele-obstetric services. Most participants viewed digital prenatal healthcare positively because it reduced transportation burdens, improved communication access, and increased psychological reassurance during pregnancy. These findings support previous studies indicating that telemedicine can strengthen patient engagement and improve emotional support in maternal healthcare services. However, this study simultaneously demonstrates that trust in digital healthcare remains conditional. Many participants continued to perceive direct physical examinations as more reliable than remote consultations, particularly for high-risk pregnancies and complex obstetric assessments.

This finding reveals an important theoretical implication regarding the relationship between technology and healthcare trust. Existing telemedicine literature frequently assumes that technological accessibility naturally increases healthcare acceptance. Yet the present study demonstrates that patient trust is mediated by communication quality, technological reliability, and perceptions regarding diagnostic legitimacy. In regions where internet instability frequently disrupts consultations, healthcare trust becomes fragile and conditional. Thus, tele-obstetric systems must be understood not merely as technological infrastructures but also as communicative and relational healthcare processes requiring institutional credibility and consistent interaction quality (Senyapar, 2024; Malik et al., 2023; Kulkov et al., 2023).

The study also contributes significantly to discussions concerning healthcare inequality and territorial governance. In Amazonas, geographic barriers remain one of the most decisive factors influencing maternal healthcare accessibility. Riverine communities often experience delayed access to emergency obstetric services because transportation infrastructure is highly dependent on environmental conditions (Fertaly et al., 2024; Chauke, 2025). Within this context, tele-obstetric systems function as compensatory healthcare mechanisms capable of reducing temporal and geographic barriers in prenatal care delivery. The findings therefore reinforce theories of spatial healthcare inequality arguing that healthcare access is deeply shaped by territorial organization and infrastructural distribution.

At the practical level, this research highlights several implications for maternal healthcare policy and digital health governance. First, tele-obstetric systems should be integrated into long-term healthcare strategies rather than treated merely as temporary technological interventions (Santamato et al., 2024; Faiyazuddin et al., 2025). The study demonstrates that digital prenatal monitoring significantly improves healthcare coordination and facilitates earlier identification of pregnancy complications. Consequently, healthcare authorities should strengthen institutional investment in telemedicine infrastructure, especially in remote maternal healthcare units.

Second, equality of infrastructure should be an integral part of the health care digitalization policy. The results reveal that technological infrastructure in communities is directly linked with the disproportionate advantages of digital health innovations and creates a risk of being excluded in isolated communities. Thus, the policy makers should strive to improve internet connectivity, electric power supply

and digital healthcare equipment at remote healthcare facilities to ensure that the distribution of these resources is equitable. If these infrastructural enhancements are not available, tele-obstetric systems are at risk of exacerbating healthcare inequalities. Third, the development of the healthcare workforce is another implication. The problems reported by a large number of the health workers were the lack of technical training and adaptation of digital systems. Thus, training in digital health is essential to build the institutional preparedness, and the quality of healthcare services, particularly in a continuous manner. Digital literacy for pregnant women and community members are also crucial, as technological access is heavily dependent on the users' familiarity with communication platforms and healthcare applications.

This study's novelty is based on the integrative analysis of the tele-obstetrics in the socio-spatial reality of the Brazilian Amazon. This is a study that does not focus on either the urban health system nor on the efficiency of digital tools as in previous studies, but that considers remote geographies characterized by infrastructure fragmentation and uneven health service distribution. Furthermore, this study has empirical evidence from a riverine community which has been underrepresented in the international literature on maternal health services. Therefore, the study brings something new to the ongoing study by presenting the link between territorial isolation and digital healthcare systems, institutional capacity and institutional adaptation practices for healthcare in the local context.

This study has limitations, however, it's crucial to take note of these. The study was conducted mainly in selected healthcare facilities and the riverine communities in the State of Amazonas, which may not be generalizable to other health care contexts in the State of Amazonas in Brazil. Secondly, a qualitative research approach was used, which included interpretative, rather than quantitative, analysis of the outcomes of healthcare. Therefore, in this research, the direct effect of the use of tele-obstetric systems on the death of mothers and clinical outcomes cannot be statistically quantified. Thirdly, Internet connection issues and transportation issues sometimes complicated entry into the field and scheduling of interviews. Comparative analyses between Brazilian regions should then be explored to determine if differences exist in implementation of digital maternal healthcare across a range of infrastructural and socioeconomic contexts in Brazil. Some quantitative or mixed methodology research also needs to be done to determine the measurable effect of the tele-obstetric systems on the decrease in maternal mortality, patient compliance with prenatal care and the efficiency of health care providers. Moreover, future studies need to explore the sustainability of the digital governance of healthcare in remote areas, not only in terms of institutional funding, technological maintenance, but also in terms of the adaptation processes in remote areas.

CONCLUSION

The findings of this research indicate that the implementation of smart prenatal care has led to a significant transformation of maternal health care services in inaccessible areas of the Amazonian state of the Federative Republic of Brazil. The use of tele-obstetrics, mobile prenatal monitoring and digital communication platforms helped enhance healthcare coordination, improve the timeliness in early identification of pregnancy risk factors, and increased continuity of prenatal care services to vulnerable maternal populations. The study reveals that despite these gains, digital maternal healthcare services have still not been realised due to lack of infrastructure equity, poor connectivity of internet, inadequate capacity building and health literacy of users and providers.

This study both theoretically contributes to the existing literature on digital health governance and illuminates the need for a socio-spatial and institutional perspective

on understanding the nature of healthcare innovation in geographically remote areas. From a practical point of view, the study suggests that the technological infrastructure should be improved, and the skills of healthcare providers should be strengthened, as well as measures for digital inclusion policies for the provision of maternal health services, to guarantee equitable access. While it is valuable, this study is not applicable to other settings in other parts of Brazil, and beyond the selected health care facilities and riverine communities in the Amazon region. Future studies are needed to include comparative and mixed methods research to evaluate the long-term impact of tele-obstetric systems on maternal health outcomes, healthcare efficiency and digital healthcare sustainability across various regional contexts.

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