The KIA (Maternal and Child Health) Telemedicine Model as a Strategic Innovation in Midwifery Services in Remote Areas of Indonesia

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ABSTRACT

Introduction: KIA or Maternal and Child Health (MCH) constitutes a critical indicator of health system performance; however, in Indonesia's remote regions, its advancement remains hindered by geographical inaccessibility, inadequate infrastructure, and limited digital literacy among healthcare providers.

Objective: This study seeks to evaluate the effectiveness of the MCH Telemedicine model in enhancing midwives' professional capacity and to establish a conceptual framework for its systematic implementation in 3T areas (underdeveloped, frontier, and outermost regions).

Methods: A sequential mixed-methods design was employed, encompassing qualitative exploration (focus group discussions and in-depth interviews), pre-experimental assessment (one-group pretest–posttest, n = 424), and a quasi-experimental approach (pretest–posttest with control group, n = 424). Quantitative analysis was conducted using paired t-tests and intergroup comparison, triangulated with qualitative findings.

Result: The exploratory phase revealed substantial barriers in service accessibility and digital literacy, although a general readiness to adopt innovation was evident. The pre-experimental phase demonstrated a significant improvement in knowledge (+25.81 points; $p < 0.001$) and digital competencies (+51 points; $p < 0.001$). In the quasi-experimental phase, the intervention group exhibited statistically significant gains, whereas the control group did not display meaningful change. These findings underscore that the effectiveness of telemedicine interventions hinges on structured implementation, empowerment of midwives, community-wide digital literacy, and coherent cross-sectoral policy alignment.

Conclusion: The proposed MCH Telemedicine conceptual model has been empirically validated as both effective and contextually appropriate for strengthening healthcare capacity in remote areas, and it holds considerable potential as a strategic framework for scaling up digital midwifery services across Indonesia.

Keywords: MCH Telemedicine, Midwifery Services, Village Midwives, 3T Regions, Digital Literacy.

Introduction

KIA or Maternal and child health (MCH) is the main foundation in the development of a nation's health. A country's success rate in reducing maternal mortality (MMR) and infant mortality (IMR) is often used as an indicator of the success of the national health system. In Indonesia, despite a significant decline in MMR from 346 deaths per 100,000 live births in 2010 to 189 per 100,000 in 2020, and a decline in IMR from 26 to 16.85 per 1,000 live births during the same period, these achievements are still above the targets set in the 2024 National Medium-Term Development Plan (RPJMN), which stipulates an MMR of 183 per 100,000 live births and an IMR of 16 per 1,000 live births {1, 2}. Moreover, Indonesia's performance still lags behind regional averages in Southeast Asia, underscoring the urgency of adopting innovative strategies to accelerate progress toward national and global health targets.

Regional disparities further exacerbate these challenges. Provincial data reveal sharp variations; for example, in Gorontalo, the MMR reached 195 per 100,000 live births in 2022, significantly exceeding the national average {3, 4, 5}. Such disparities reflect inequities in the distribution of health services, particularly in remote, rural, and island settings. Village midwives, who serve as the frontline providers of maternal and child health services in these contexts, encounter a range of systemic barriers: inadequate infrastructure, long geographical distances, scarcity of medical equipment, shortages of skilled personnel, and socio-cultural resistance to modern healthcare practices. Within this complex environment, the integration of information and communication technologies (ICT) through telemedicine has been posited as a transformative approach. Telemedicine offers the potential to overcome temporal and spatial barriers, extend access to consultations, diagnostic services, and health education, and enhance the overall quality of midwifery care {6, 7, 8, 9, 10}. Yet, its effectiveness in the context of rural midwifery in Indonesia warrants rigorous empirical examination.

Despite its promise, the implementation of telemedicine remains paradoxical. On the one hand, healthcare professionals often report favorable perceptions, citing improved access, time efficiency, and ease of use {11, 12}. High levels of satisfaction with telemedicine platforms have also been documented among medical personnel {13, 14, 15}. On the other hand, these perceptions frequently collide with practical realities in remote settings. For many midwives, telemedicine cannot substitute face-to-face consultations, as physical examinations, central to accurate diagnosis and case management, are difficult to replicate virtually. Furthermore, persistent infrastructural deficits, including unstable internet connectivity, unreliable electricity, and suboptimal application quality, undermine confidence in telemedicine's reliability. Additional tensions arise from theoretical frameworks. Studies grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT) have found that facilitating conditions do not significantly influence telemedicine adoption {16, 17}. This finding stands in stark contrast to realities in rural Indonesia, where enabling conditions such as network availability, equipment, and training are indispensable. The disjuncture between theoretical assumptions and contextual realities renders telemedicine both contested and in need of locally grounded inquiry.

Although the literature on telemedicine in Indonesia is expanding, significant research gaps remain. Much of the existing scholarship concentrates on general healthcare delivery without situating midwives as pivotal actors in MCH services in remote regions. Moreover, socio-cultural dimensions, including cultural diversity, digital literacy, and prevailing social norms, are seldom integrated into analyses. Preliminary studies suggest that midwives' acceptance of telemedicine is shaped by performance expectations, effort expectations, social influence, and facilitating conditions, which are often contingent upon government-led socialization and training programs {18, 1}. Previous projects have also tended to emphasize short-term interventions, overlooking sustainability dimensions such as regulatory frameworks, financing, and cross-sectoral collaboration. These limitations highlight the need for comprehensive, integrative research capable of generating a context-sensitive MCH telemedicine model.

Evidence from other developing countries underscores both the potential and constraints of telemedicine. Studies in Africa and Ethiopia have demonstrated significant gains in antenatal care (ANC) attendance, facility-based deliveries, and

immunization coverage following telehealth interventions {20, 21, 22}. Similarly, SMS-based telemedicine in Kenya has proven effective in enhancing maternal health education {23, 24]}. Nevertheless, limitations such as low digital literacy, concerns about data security, and infrastructural deficits persist. Indonesian studies echo these findings: while mobile-based applications have expanded access to consultations, their effectiveness remains heavily dependent on infrastructure, provider training, and patient trust {19, 26, 27, 28}. Systematic reviews further emphasize that telemedicine's success is not merely a technological issue but is deeply intertwined with trust, social influence, and eHealth literacy {29, 30, 31, 32}. Yet, little empirical attention has been devoted to these dynamics in the specific context of midwifery services in rural Indonesia, despite their critical importance.

Case studies on the use of TeleCTG demonstrate telemedicine's potential to equalize maternal health service provision in contexts with limited specialist availability {33, 34, 6}. However, these studies also stress that the technology cannot succeed without active midwife participation, reinforcing the necessity of professional empowerment. Likewise, collaborative initiatives such as those between BPJS Kesehatan and PT Pos Indonesia illustrate the value of cross-sectoral partnerships in extending telemedicine's reach to underserved communities. These examples underscore that telemedicine should not be reduced to a digital platform but must be embedded within a broader healthcare ecosystem encompassing logistics, financing, and stakeholder coordination.

Against this backdrop, the present study aims to advance beyond fragmented analyses by constructing a holistic MCH telemedicine framework. Specifically, the study seeks to: (1) analyse the critical components of an effective telemedicine model for remote areas; (2) evaluate its impact on MCH indicators such as ANC frequency, immunization compliance, and referral effectiveness; (3) identify enablers and barriers to implementation with particular emphasis on midwives and rural communities; and (4) formulate policy recommendations to support the adoption and scalability of sustainable telemedicine models in Indonesia.

This research contributes to the literature by offering an integrative conceptual framework that synthesizes technology adoption theory (UTAUT2) with dimensions of health worker empowerment and system sustainability. In doing so, it not only extends scholarly discourse but also provides actionable insights for policymakers, NGOs, and healthcare providers. Ultimately, the study advances both academic knowledge and practical solutions toward achieving Indonesia's national targets for reducing MMR and IMR.

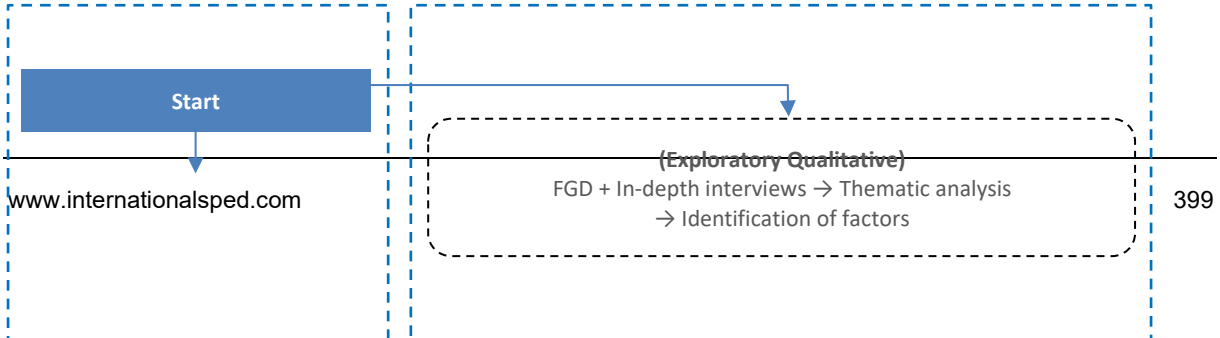
Materials and methods

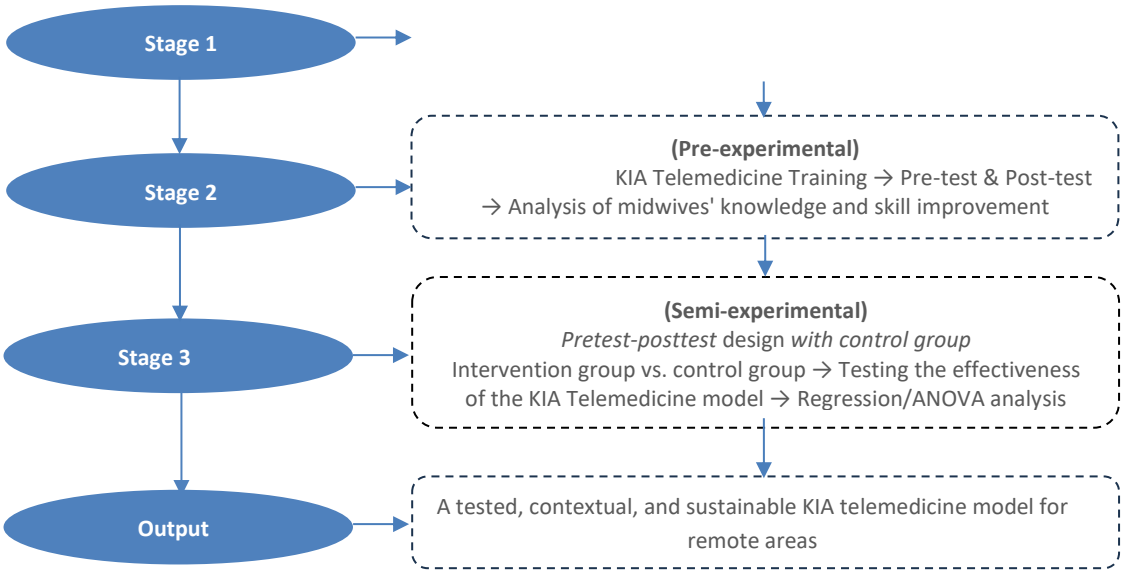
Research Design

This study employed a mixed-methods approach with a sequential explanatory design, integrating qualitative and quantitative components in successive phases to provide a comprehensive understanding of the effectiveness of the Maternal and Child Health (MCH) Telemedicine model in remote areas. This design was deemed appropriate given the necessity to first explore in depth midwives' perceptions, experiences, and challenges through Focus Group Discussions (FGDs) and in-depth interviews, followed by the quantitative testing of telemedicine interventions via a quasi-experimental design.

The research was conducted in three main phases. The first was a qualitative exploratory phase, which examined midwife empowerment, structural barriers, and opportunities for implementing MCH telemedicine through FGDs and in-depth interviews. The second was a pre-experimental intervention phase, in which telemedicine training was delivered using a pre–post-test design to measure changes in midwives' competencies before and after the intervention. The third was a quasi-experimental phase, adopting a pretest–posttest control group design to rigorously evaluate the effectiveness of the MCH telemedicine model on midwifery service indicators by comparing outcomes between the intervention and control groups.

Figure 1. Flow Diagram of Research Phase





Research Subject

The study population comprised 10,617 midwives across 3,349 villages and subdistricts in 28 districts/cities spanning three provinces in Kalimantan (East, South, and North). Sampling was conducted purposively, with inclusion criteria specifying midwives holding a minimum of a Diploma III in Midwifery, aged ≥ 22 years, with at least one year of professional experience in remote villages, actively engaged in midwifery practice, and possessing digital devices for daily use {36, 37}. Exclusion criteria included respondents with psychological disorders, those without post-graduation practice experience, and those on leave for more than six months.

Using the Slovin formula {38}. with a 5% margin of error, the minimum required sample size was 385. To account for potential attrition, 10% was added, yielding a final sample of 424 midwives distributed across six districts in three provinces.

Data Collection Techniques

Data collection in this study was carried out using several complementary techniques. Focus Group Discussions (FGDs) were employed to explore midwives' understanding and experiences regarding telemedicine-based maternal and child health services, while in-depth interviews provided a more detailed account of perceptions, barriers, and implementation needs. In addition, observation and questionnaires were applied during the pre–post-test and quasi-experimental phases to measure changes in knowledge, digital skills, and the quality of midwifery services. Documentation, in the form of medical records, service logs, and health program reports, was also used as supporting data sources. To enhance validity, triangulation techniques were applied by combining the results of interviews, observations, and quantitative surveys.

Research Instruments

This research instrument was developed based on a literature review and the adoption of instruments that have been proven valid and reliable in previous studies, in order to ensure the accuracy and credibility of the results. The instruments include a *Focus Group Discussion* (FGD) guide and in-depth interviews containing open-ended questions related to midwives' experiences, technical constraints, socio-cultural factors, and telemedicine implementation support needs. To measure midwives' knowledge, digital skills, and attitudes, this study adapted the Telemedicine Awareness, Knowledge, Attitude, and Skills (AKAS) Questionnaire validated by {39]} with very high reliability (*Cronbach's alpha:* Awareness = 0.950; Knowledge = 0.851; Attitude = 0.970; Skills = 0.952) and strong construct validity (KMO > 0.90; Bartlett's Test significant, $p < 0.001$). Additionally, the ease of use of the telemedicine application was assessed using the Indonesian version of the Telehealth Usability Questionnaire (TUQ) validated by {40}, with an overall reliability of $\alpha = 0.958$, sub-scales of Ease of Use & Learnability = 0.907, and Reliability = 0.794, as well as excellent construct validity (KMO = 0.926; $p < 0.001$). An additional instrument in the

form of an observation sheet was used to assess midwives' practical skills in operating KIA telemedicine, while medical records were used to assess service indicators, including the number of antenatal care (ANC) visits, timely referrals, and immunisation compliance.

Data Analysis

Data analysis was conducted in two stages according to the *mixed methods* approach. First, qualitative analysis used *thematic analysis* of FGD and interview data, through the process of transcription, *coding*, categorisation, and identification of main themes related to supporting factors, barriers, and midwife empowerment strategies. Second, quantitative analysis used SPSS, including paired t-tests (pre–post test), *independent sample t-tests* or ANOVA (differences between intervention and control groups), and regression/logistics (predictors of telemedicine success).

Results

Respondent Characteristics

A total of 424 midwives from six districts in East Kalimantan, South Kalimantan, and North Kalimantan provinces participated in this study. The analysis of respondent characteristics was conducted to provide an overview of the health personnel who constituted the focus of the study, particularly in relation to their professional experience, educational background, and the geographical conditions of the areas in which they practised. Table 1 presents the distribution of respondents according to age, level of education, and length of work experience.

Table 1. Characteristics of Research Respondents (n=424)

Characteristics	Category	Number	Percentage
Age	22–30 years	148	34.9
	31–40 years	117	27.6
	Over 40 years old	159	37.5
Education	DIII Midwifery	304	71.7
	DIV/Bachelor's Degree in Midwifery	92	21.7
	Master's/Doctorate	28	6.6
Years of Experience	<5 years	194	45.9
	≥5 years	230	54.1

The descriptive results in Table 1 indicate that the majority of respondents were within the productive age group, namely 22–40 years (62.5%). This reflects the availability of relatively young midwives in their peak productivity phase, which is expected to support the adoption of technology-based innovations such as telemedicine. In terms of education, most respondents held a Diploma III in Midwifery (71.7%), while only a small proportion possessed a bachelor's or master's degree (6.6%). This suggests that midwives in remote areas generally come from vocational education backgrounds, which emphasise practical skills rather than an academic orientation. Furthermore, the distribution by length of service shows that more than half of the respondents (54.1%) had at least five years of work experience. This finding underscores that the respondents possess considerable practical competence in addressing the dynamics of midwifery services in villages. However, their experience is constrained by significant structural barriers, particularly limitations in infrastructure and technology. Additional analysis revealed that 68.9% of respondents worked in areas with difficult road access, while 72.4% reported limited internet connectivity. Overall, the description of respondent characteristics confirms that the midwives in the study area not only present a representative demographic profile but also face tangible challenges in infrastructure and technology access. These conditions highlight the

urgency of developing a maternal and child health (MCH) telemedicine model that is adaptive to the geographical and socio-technological context of remote areas in Indonesia.

Exploratory Stage of Maternal and Child Health Services in Remote Areas

The exploratory phase of this research was undertaken to gain an in-depth understanding of the real conditions of maternal and child health (MCH) services in remote areas, particularly in the provinces of East Kalimantan, South Kalimantan, and North Kalimantan. Data collection was conducted through Focus Group Discussions (FGDs) and in-depth interviews involving village midwives, health centre personnel, and pregnant women. This qualitative approach enabled the researchers to explore experiences, challenges, and potential innovations that could be developed in practice. The findings from this stage identified three main issues that represent both challenges and opportunities in developing telemedicine-based services, namely limited access to MCH services, low digital literacy, and initial readiness for digital innovation. Table 2 summarises the principal findings obtained from the FGDs and in-depth interviews.

Table 2. Key Findings from FGDs and Interviews in the Exploration Phase

Main Theme	Field Findings	Representative Quotes
Limited Access	Long distances, poor infrastructure, uneven distribution of health workers.	*"We often have to travel more than 2 hours to refer pregnant women."* (Midwife, East Kalimantan)
Low Digital Literacy	Midwives have digital devices, but they are rarely used for services; minimal training; the community is not yet accustomed to online consultations.	*"I have a mobile phone, but only for WhatsApp. I have never used it for patient consultations."* (Midwife, South Kalimantan)
Readiness for Innovation	Midwives and pregnant women are willing to accept telemedicine provided there is training and guidance.	*"If there is an application, we are willing to try it, as long as there is someone to guide us."* (Pregnant woman, North Kalimantan)

The findings presented in Table 2 demonstrate a clear gap between the availability of digital devices and the ability to utilise them effectively. On the one hand, midwives already possess smartphones and other digital tools, yet their use in midwifery services remains very limited. Low levels of digital literacy, both among health workers and within the community, constitute a major obstacle. On the other hand, there are positive indications of openness towards the adoption of telemedicine when accompanied by training, technical guidance, and institutional support. These findings therefore confirm that the challenges of MCH services in remote areas are not confined to physical infrastructure, but also extend to technological capacity and digital literacy. Nevertheless, the initial readiness of midwives and communities presents strategic opportunities for developing an MCH telemedicine model that is more adaptive to local conditions.

Pre-Experimental Stage of Telemedicine Training Effectiveness

In the second stage, this study examined the effectiveness of telemedicine training through a one-group pre-test–post-test design involving 424 village midwives. The training intervention was structured around practical activities and midwifery case simulations, with the objective of enhancing midwives' competence in employing digital technology for maternal and child health services (MCH).

The measurement results are presented in Table 3. Statistically, there was a significant improvement in two key indicators, namely telemedicine-related midwifery knowledge and digital skills. The mean knowledge score increased from 61.42 (SD ± 8.71) to 87.23 (SD ± 6.92), reflecting a gain of +25.81 ($p < 0.001$).

Similarly, digital skills rose substantially from 38.00% (SD ± 4.60) to 89.00% (SD ± 4.20), with an increase of +51.00 ($p < 0.001$).

Table 3. Results of Pre-Test and Post-Test of Midwives' Digital Knowledge and Skills

Variable	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	Δ (Difference)	p-value
Knowledge (0–100)	61.42 ± 8.71	87.23 ± 6.92	+25.81	<0.001
Digital Skills (%)	38.00 ± 4.60	89.00 ± 4.20	+51.00	<0.001

Qualitative analysis corroborates these findings, with midwives reporting enhanced confidence and more positive attitudes towards the use of technology following practice-based training. The real-case simulation approach proved highly relevant, as it provided applicable hands-on experience that strengthened midwives' ability to identify pregnancy risks and to make application-based referrals. Hence, the pre-experimental stage confirms that telemedicine training can substantially enhance midwives' capacity, not only in terms of knowledge and digital skills, but also by fostering psychological readiness to embrace technology-based healthcare innovations.

Semi-Experimental Phase: Testing the Effectiveness of the Intervention

The third stage of this study used a *pretest–posttest with control group* design with a total of 424 midwives, divided evenly into an intervention group (n = 212) and a control group (n = 212). This design was chosen to more rigorously test the effectiveness of KIA-based telemedicine training in improving midwives' capacity, while comparing the differences in changes between the two groups.

The measurement results are presented in Table 4. In the intervention group, the average knowledge score increased significantly from 60.86 to 86.56 with a difference of +25.70 (p < 0.001). In contrast, the control group only experienced a marginal increase from 60.53 to 62.48 with a difference of +1.95, which was not statistically significant. A similar pattern was observed for the digital skills variable, where the intervention group showed a substantial increase from 38.73 to 89.39 ($\Delta = +50.66$; $p < 0.001$), while the control group only increased slightly from 38.41 to 40.40 ($\Delta = +1.99$; ns).

Table 4. Comparison of Midwives' Digital Knowledge and Skills Scores in the Intervention and Control Groups

Variable	Group	Pre-Test (Mean)	Post-Test (Mean)	Δ (Difference)	p-value
Knowledge	Intervention	60.86	86.56	+25.70	<0.001
	Control	60.53	62.48	+1.95	ns
Digital Skills	Intervention	38.73	89.39	+50.66	<0.001
	Control	38.41	40.40	+1.99	ns

These findings consistently show that telemedicine interventions have a significant impact on improving midwives' digital knowledge and skills. The absence of significant changes in the control group reinforces the validity of the results that the improvement in midwives' competence stems from the intervention provided, rather than from external factors. Thus, this quasi-experimental stage provides strong evidence of the effectiveness of telemedicine as a strategy for empowering health workers in remote areas.

Conceptual Model of Telemedicine for Maternal and Child Health

Based on the findings of the exploratory, pre-experimental, and quasi-experimental stages, a conceptual model of Telemedicine for Maternal and Child Health (MCH) was developed, designed to enhance the quality of midwifery services in remote areas. The figure illustrates an integrated conceptual model of a telemedicine system specifically focused on maternal and child health services. The model adopts an ecosystem approach in which all essential components interact dynamically to achieve the overarching goal of improving both accessibility and quality of health services in geographically disadvantaged areas. It integrates four key components that are mutually interconnected.

Figure 2. Conceptual Model of Telemedicine for Maternal and Child Health in Remote Areas of Indonesia

This model visually represents the reciprocal relationships among the components. The circular arrows signify the continuous and interdependent nature of these interactions, with each pillar influencing and being influenced by the central hub. For instance, health workers utilise technology to engage with patients, while the success of these interactions relies on the support of government and partner institutions. Overall, the figure illustrates a cohesive ecosystem, where the effectiveness of the MCH telemedicine system is contingent not only on technological infrastructure but also on the integration of human resources, community engagement, and institutional support. This model consists of four main pillars that are interconnected through a central hub labelled "*Conceptual Model: Telemedicine System for Maternal & Child Health*".

Technology Components This pillar is the technical foundation that enables the system to operate. Its components include:

– *Telemedicine Application*

A software platform that facilitates clinical communication, including synchronous and asynchronous consultations, and is equipped with Electronic Medical Record (EMR) and pregnancy risk detection features.

– *Internet Network & Digital Devices*

Connectivity infrastructure and *hardware* (such as *smartphones* and laptops) that are crucial for data transfer and *real-time* interaction.

– *Data Security & Patient Privacy*

A critical aspect ensuring the protection of sensitive information, in accordance with medical regulations and ethics.

Health Worker Components This pillar focuses on the human resources delivering the services. It includes:

– *Midwives (Frontline Consultants)*

Serving as the frontline providers who offer direct consultations and facilitate the use of technology at the community level.

– *Health Cadres (Digital Literacy Facilitators)*

Functioning as facilitators who assist the community in adopting and understanding digital services.

Patient/Community Components This pillar is the subject and social environment of the services. Its elements are:

– *Family (Postpartum Women & Infants)*

The primary target group that directly benefits from the system, including postpartum women and infants.

– *Local Community (Digital Innovation Acceptance)*

The social environment that influences the level of adoption and sustainability of innovation, demonstrating the importance of social acceptance of the system.

Government & Partner Support Components This pillar provides the institutional and financial foundation for the sustainability of the model. Its components consist of:

– *Local Government (Regulation, Funding, Supervision)*

Institutions that set regulations, provide funding, and conduct supervision.

– *Private Partners/NGOs (Platform, Training, Mentoring)*

Entities that contribute by providing technology platforms, training, and implementation mentoring.

– *BPJS Health (Financing Integration)*

The institution that plays a crucial role in integrating telemedicine services into the national health financing system.

Discussion

The findings of this research, obtained through a three-stage design (exploratory, pre-experimental, and quasi-experimental), provide consistent empirical evidence regarding the transformative potential of telemedicine in maternal health care. Quantitative data revealed substantial improvements in knowledge (+25.81 points) and digital skills (+51 points) following the intervention, while qualitative insights demonstrated positive attitudinal shifts among midwives towards the use of technology. Collectively, these results confirm the research hypothesis and reinforce the argument that technological innovation, when accompanied by structured training and systemic support, can effectively mitigate the health service deficits experienced in 3T (underdeveloped, frontier, and outermost) regions.

Several key insights emerge from the analysis. First, the demographic profile of respondents shows that most midwives were of productive age, possessed vocational qualifications, and had accumulated substantial professional experience. These characteristics indicate a strong potential for telemedicine adoption, as midwives in their productive years are generally more responsive to technological change. However, infrastructural barriers specifically poor road networks and inadequate internet coverage (reported by 68.9% and 72.4% of respondents, respectively) remain critical constraints. Second, exploratory findings confirm the existence of a digital literacy gap among both midwives and communities. Despite relatively widespread ownership of digital devices, their utilisation for professional health services remains limited. Nevertheless, there was an observable openness to innovation, contingent upon the provision of training and technical assistance. Third, pre-experimental results demonstrate that structured telemedicine training significantly enhanced midwives' knowledge and competencies. These improvements extended beyond statistical significance to practical relevance, especially in risk identification during pregnancy, online consultations, and digital communication with patients. Fourth, the quasi-experimental phase provided robust evidence that improvements occurred exclusively in the intervention group, highlighting the indispensability of structured interventions in capacity development. On this

basis, the study proposes a conceptual model of Telemedicine KIA which integrates technological platforms, health workers, patients and communities, alongside governmental and multi-sectoral support.

Theoretically, these findings align with several established frameworks. The Unified Theory of Acceptance and Use of Technology (UTAUT2) underscores that adoption is shaped by performance expectations, social influence, facilitating conditions, and habituation {41, 42, 43, 44}. In this study, enhanced digital skills and attitudinal change following training illustrate strengthened performance expectations and facilitated conditions. Similarly, experiential learning theory {45, 46, 47, 48} supports the effectiveness of simulation-based learning, evident as midwives transitioned from viewing technology as a tool for personal communication to mastering professional telemedicine applications. Furthermore, the conceptual model developed here underscores that innovation in health technology cannot succeed in isolation but must be embedded within systemic structures of regulation, financing, and governance. This resonates with broader perspectives on health system strengthening [49, 50], which emphasise institutional integration as a prerequisite for sustainability.

In terms of external validity, these results are congruent with international research. Studies in Ethiopia highlight telemedicine's capacity to improve antenatal compliance and expedite detection of complications {51, 52, 53}. Evidence from India indicates reductions in referral delays through remote consultation platforms {54, 55, 56, 57, 58}. In Indonesia, research on TeleCTG similarly confirms telemedicine's contribution to remote pregnancy monitoring {59, 34}. The present study adds novelty by framing telemedicine through a multi-sectoral lens, including the involvement of BPJS Kesehatan, NGOs, and private sector partners, thereby extending the discourse beyond technical efficacy to long-term sustainability and collaborative governance.

Notwithstanding these contributions, several challenges warrant consideration. Firstly, deficiencies in digital infrastructure cannot be overcome by training alone. Adaptive technological solutions, such as offline-capable applications, should be developed to accommodate limited connectivity. Secondly, low levels of digital literacy among pregnant women may reduce the effectiveness of interventions. To address this, community-based communication strategies are necessary to foster acceptance and capability. Thirdly, sustainability is contingent on regulatory and financial alignment. Without integration into the national health insurance system (BPJS) and explicit regulatory frameworks, the Telemedicine KIA Model risks limited scalability. Accordingly, the study proposes three strategic pillars for sustainable implementation: (1) continuous professional development of midwives through blended learning; (2) context-sensitive investment in digital infrastructure; and (3) integration of telemedicine into national policy and financing systems.

The contributions of this study are both theoretical and practical. Theoretically, it expands the literature on digital health adoption in remote settings by incorporating dimensions of digital literacy, innovation readiness, and cross-sectoral collaboration. Practically, it introduces a conceptual model of Telemedicine KIA (Maternal and Child Health) as a strategic blueprint for policymakers, local governments, and private or non-governmental stakeholders to strengthen health services in geographically disadvantaged regions. The model also has potential replicability in other low- and middle-income countries facing similar challenges.

This study, however, is not without limitations. The geographical scope was confined to three provinces in Kalimantan, thus caution should be exercised in generalising findings nationally. Furthermore, moderating factors such as cultural context and infrastructural variance were not examined in depth, leaving room for future studies to explore these dimensions. These limitations, rather than detracting from the study, offer fertile ground for subsequent research aimed at advancing knowledge on the systemic integration of telemedicine in resource-constrained environments.

Conclusion

This study demonstrates that the Maternal and Child Health (MCH) Telemedicine model constitutes an effective and innovative strategy for enhancing midwives' professional capacity and widening access to maternal services in remote regions of Indonesia. The sequential stages of the research yielded consistent evidence.

First, the exploratory phase identified limited service availability and low levels of digital literacy, yet also revealed a readiness among midwives to embrace innovation. Second, the pre-experimental phase confirmed that structured telemedicine training produced significant improvements in knowledge (+25.81 points) and digital skills (+51 points). Third, the quasi-experimental phase showed that these improvements were confined to the intervention group, thereby substantiating the effectiveness of technology-based training and mentoring strategies.

Beyond these empirical findings, the study advances a conceptual model of MCH Telemedicine that integrates four essential components: technological infrastructure, health workers, patients and communities, and government and partner support. The success of implementation is therefore not solely contingent upon access to digital devices, but equally dependent on midwife empowerment, improved digital literacy, and the establishment of cross-sectoral regulatory and financial mechanisms. This dual emphasis, on both human capacity and systemic support, positions the model as a strategic framework for the sustainable adoption of health technology in 3T (underdeveloped, frontier, and outermost) settings.

The contributions of this study are both theoretical and practical. Academically, it enriches the literature on digital health adoption in resource-constrained regions by addressing the dimensions of capacity-building, literacy, and cross-sectoral collaboration. Practically, it provides policymakers, local governments, and non-governmental actors with a blueprint for strengthening technology-based midwifery services in remote areas. While the study was confined to three provinces in Kalimantan and did not directly measure macro-level health outcomes, such as maternal mortality rates (MMR) and infant mortality rates (IMR), it nevertheless establishes a solid foundation for more comprehensive future research. In this regard, three avenues for further enquiry are recommended.

First, a cost-effectiveness analysis should be undertaken to assess the financial viability and efficiency of implementation. Second, longitudinal studies are required to evaluate the long-term effects of telemedicine on MMR and IMR. Third, mixed-methods research is necessary to explore the socio-cultural dynamics that shape community acceptance of digital health interventions. Together, these lines of enquiry will not only deepen scholarly understanding but also strengthen the evidence base required for policy and practice in advancing maternal health equity through telemedicine.

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