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Enhancing Health Services Through Telemedicine: Addressing the Gaps in LBW Monitoring and Training at *Puskesmas* Gedangan, Sidoarjo Regency

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ABSTRACT *Puskesmas* in Sidoarjo Regency, including *Puskesmas* Gedangan, currently lack real-time monitoring facilities for low birth weight (LBW) infants that can be accessed through Android-based telemedicine systems. This limitation hinders both healthcare workers and families in continuously observing infant health conditions, particularly when the infants are placed in intensive care units. Additionally, insufficient training on the operation and maintenance of telemedicine-based baby incubators contributes to reduced service quality. This community service initiative aimed to enhance the capacity of health workers and family caregivers in utilizing telemedicine-based baby incubator technology to improve neonatal care services. The program adopted a participatory approach through the Community Partnership Program, involving counseling, hands-on training, and continuous mentoring conducted by lecturers and students from the Health Polytechnic of the Ministry of Health Surabaya. Activities included the installation of telemedicine-integrated baby incubators, training sessions on device operation and maintenance, and regular monitoring and evaluation over a three-month period to assess adherence to standard operating procedures (SOPs). The results showed significant improvement in the knowledge and skills of *Puskesmas* Gedangan health workers regarding the operation, maintenance, and monitoring of telemedicine-based incubator devices. The application of this technology enhanced healthcare accessibility, facilitated faster response to patient conditions, and enabled family participation in infant monitoring. In conclusion, implementing telemedicine-based baby incubators has proven effective in improving neonatal health services at the community level. Despite challenges such as limited internet access and technical capacity, this initiative demonstrates that integrating telemedicine into primary healthcare can enhance service efficiency, equity, and quality of care for infants requiring intensive monitoring.

INDEX TERMS Telemedicine, baby incubator, low birth weight, community health services, *Puskesmas* Gedangan

I. INTRODUCTION

Low birth weight (LBW) remains a major contributor to neonatal morbidity and mortality worldwide. The World Health Organization (WHO) estimates that approximately 20 million LBW infants are born each year, representing about 15.5 % of all births globally [1]. In Indonesia, the national LBW prevalence is estimated at 6.2 %, with a higher proportion in several provinces including East Java [2]. These infants are at greater risk of infections, growth retardation, and developmental disorders, which require continuous monitoring and specialized care [3]. However, most community health centers (*Puskesmas*) in Indonesia, including *Puskesmas* Gedangan in Sidoarjo Regency, lack telemedicine-based monitoring systems that allow real-time observation of infant conditions by health workers or family caregivers [4]. Additionally, training programs for the operation and maintenance of medical devices particularly telemedicine-based baby incubators remain limited [5]. This situation constrains the quality of neonatal health services and delays early interventions for at-risk infants [6].

Recent developments in telemedicine and the Internet of Medical Things (IoMT) have provided innovative solutions for remote health monitoring [7], [8]. Several studies have demonstrated the effectiveness of real-time monitoring systems for neonatal intensive care units (NICUs), integrating wireless sensors and cloud-based platforms [9]–[11]. Systems using microcontrollers and machine-to-machine communication have enabled continuous observation of neonatal parameters such as temperature, oxygen saturation, and heart rate [12], [13]. Furthermore, teleconsultation and tele-nursing services have improved the quality of neonatal care by facilitating rapid medical decisions and reducing hospital readmissions [14]–[16]. In low-resource settings, cost-effective frugal innovations such as IoT-enabled baby incubators have been developed to bridge technological gaps [17], [18]. However, these systems are primarily designed for hospital settings and often lack integration into community-level health infrastructure.

Despite technological advances, there remains a significant gap in the implementation of telemedicine-based monitoring systems at the community healthcare level. Current solutions focus on tertiary hospitals or NICU environments rather than decentralized health centers [19]. Furthermore, few initiatives include structured user training for nurses, midwives, and family caregivers [20]. Limited technical capacity, inadequate infrastructure, and insufficient evaluation mechanisms hinder sustainable adoption [21]. Therefore, a participatory and context-specific model integrating technology transfer, human-resource capacity building, and systematic evaluation is urgently required to strengthen neonatal healthcare services in primary care settings.

This study aims to implement and evaluate the application of a telemedicine-based baby incubator system at *Puskesmas* Gedangan, Sidoarjo Regency. The primary goal is to enhance the competencies of healthcare personnel and family caregivers in utilizing the device for monitoring and maintaining the health of LBW infants, thereby improving the overall quality and accessibility of neonatal care. This paper contributes to the growing body of research on community-based telemedicine through three main aspects:

1. TECHNOLOGICAL INTEGRATION
   Development and application of a telemedicine-based baby incubator equipped with IoT sensors for real-time infant monitoring.
2. CAPACITY BUILDING
   Implementation of structured training and mentoring for healthcare workers and caregivers to ensure sustainable device operation and maintenance.
3. SERVICE QUALITY ENHANCEMENT
   Evaluation of service improvement outcomes in terms of accessibility, response time, and family involvement in neonatal care.

The remainder of this article is organized as follows: Section II explains the methods and implementation framework of the community service program. Section III presents the results of the telemedicine-based baby incubator application and evaluation. Section IV discusses findings in relation to previous studies, limitations, and implications for future health service innovation. Section V concludes with key insights and recommendations.

II. METHOD

A. STUDY DESIGN

This research adopted a prospective experimental community-based design, conducted at *Puskesmas* Gedangan, Sidoarjo Regency, East Java, Indonesia, from March to July 2024. The study combined technological intervention, structured training, and mentoring activities.

B. STUDY POPULATION AND SAMPLING

The target population consisted of healthcare workers and caregivers involved in neonatal care at *Puskesmas* Gedangan. A purposive sampling technique was applied to recruit participants directly related to LBW infant management. A total of 20 participants were included: 8 nurses, 6 midwives, and 6 non-medical caregivers. Inclusion criteria were active involvement in neonatal services, willingness to participate in all training sessions, and informed consent to data collection. Exclusion criteria were participants unable to complete the training or evaluation phase. Because the activity emphasized professional skill development rather than inter-group comparison, randomization was not applied, and no control group was established.

C. MATERIALS AND EQUIPMENT

The primary device used was the telemedicine-based baby incubator prototype developed by the Department of Electromedical Engineering, Poltekkes Kemenkes Surabaya. The device comprised several subsystems

1. CORE COMPONENTS
   Arduino Mega 2560 microcontroller, ESP8266 Wi-Fi module for wireless connectivity, and a 7-inch LCD touchscreen as a user interface.
2. SENSORS
   DHT22 for humidity and air temperature, MLX90614 infrared sensor for infant temperature, and MAX30102 for heart-rate monitoring.
3. POWER SYSTEM
   12 V DC regulated supply with lithium-ion battery backup supporting up to 2 hours of autonomous operation.
4. DATA INTEGRATION
   Cloud-based data transfer using Firebase IoT protocol, encrypted under TLS 1.3 standards.
5. SOFTWARE
   Android application built in Kotlin, enabling real-time data visualization and alert notification for both healthcare workers and caregivers.

All modules were calibrated before installation according to ISO 13485:2016 standards for electromedical devices [22]. The telemedicine network was configured through a secure Wi-Fi LAN with backup offline data logging to ensure continuous operation during temporary connectivity loss [23].

D. DATA COLLECTION INSTRUMENTS AND ANALYSIS

Data comprised two categories:

1. Technical parameters, including temperature deviation (°C), humidity (%RH), heart-rate error (bpm), network latency (s), and alarm response time (s).
2. Human performance metrics, such as mean knowledge-score improvement (pre- vs post-test) and adherence to operational SOPs (% compliance).

Sensor performance was verified against standard reference devices (Fluke Biomedical VT650 Calibrator). Data were analyzed using descriptive statistics and paired t-tests with a significance level of $p < 0.05$. All analyses were performed using IBM SPSS Statistics v. 27 software [27].

E. DATA ANALYSIS

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Validation tests were conducted for both device accuracy and training instruments. Temperature and humidity readings showed deviations within ± 0.2 °C and ± 2 % RH, meeting WHO neonatal incubator specifications [28]. The training evaluation questionnaire obtained a Cronbach's α value of 0.88, indicating high internal reliability. Equipment durability was verified through a continuous 48-hour stress test without performance degradation.

This study was limited by its small sample size (n = 20) and single-site implementation. Network instability during peak hours occasionally caused delayed data synchronization. Despite these limitations, the methods presented provide a replicable framework for broader application across primary healthcare centers [29], [30].

F. ETHICAL CONSIDERATIONS

Participant confidentiality was maintained through anonymized identifiers. Access to telemedicine data required password-protected credentials limited to authorized personnel. The incubator was equipped with over-temperature alarms (> 38 °C) and automatic fan cut-off to prevent infant overheating. Emergency protocols were established in collaboration with *Puskesmas* Gedangan medical staff.

G. WORK FLOW OF IMPLEMENTATION

The project implementation followed four sequential phases**:** preparation, training, operational testing, and monitoring each designed for reproducibility. The model of Community Service activities carried out for counselling activities is accompanied by mentoring activities for a certain period carried out by lecturers, and students in the form of academic activities. While the activity method is carried out through presentations and demonstrations using the necessary tools and teaching materials, namely baby incubators [23].

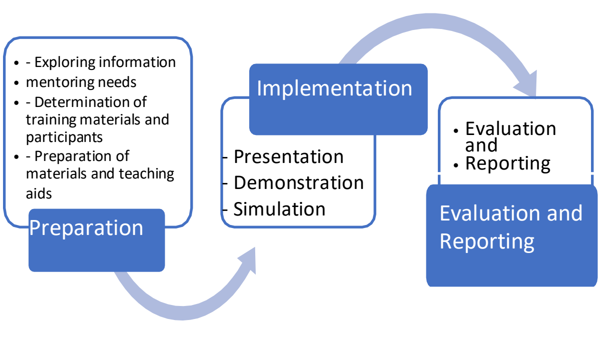

Figure 1
Flow of Activity Implementation

The workflow of the implementation process, including preparation, training, application use, and evaluation phases, is depicted in FIGURE 1. This figure provides a visual overview of the procedural steps undertaken throughout the community engagement program. The steps of the Community Service activity plan are as follows.

1. PREPARATION PHASE

Coordination meetings were held with the Head of *Puskesmas* to define training schedules, participants, and room arrangements. The incubator system was installed in the neonatal care room, and Android applications were pre-installed on participants' smartphones. Connectivity, power stability, and data logging were tested prior to initiation.

2. IMPLEMENTATION.

This Community Service activity, the proposing team involves students. The head of the proposing team is a lecturer who has expertise in the field of electromedical science and nursing science and electromedical science. While the students involved in this Community Service activity are Semester 4 of the Applied Bachelor of Electromedical Engineering Technology study programme. In conducting community service activities in the Gedangan *Puskesmas* environment by using a telemedicine-based Baby Incubator tool which is the result of research by a team of lecturers involving students [24]. Community Service activities carried out for counselling activities are accompanied by mentoring activities carried out through presentations and demonstrations using the necessary tools and teaching aids, namely baby incubators.

The following is the implementation plan for the Telemedicine-based Baby Incubator Tool:

a. Training phase
Participants attended a structured two days (8-hour/day) session covering introduction to telemedicine concepts, operating procedures for the baby incubator, preventive maintenance and basic troubleshooting, and hygiene protocols for neonatal equipment. The format combined lectures, hands-on demonstrations, and supervised simulation exercises. Competency was assessed using a standardized skill checklist and written pre-/post-tests [25].

Figure 2 **Front view of the Integrated Laboratory of the Health Polytechnic of the Ministry of Health Surabaya.**

b. Operation Stage.
After training, the participants operated the incubator under supervision for real patients requiring LBW care. Real-time data temperature, humidity, and heart rate were transmitted every 60 seconds to the Firebase dashboard. Health workers adjusted temperature and humidity settings in response to alerts, while caregivers accessed live updates via the Android application. Daily logs were automatically stored for analysis [25].

c. Monitoring and Evaluation Phase
Monitoring continued over three months to assess adherence to Standard Operating Procedures (SOPs) and device reliability. Weekly on-site visits were conducted to inspect mechanical function, sensor accuracy, and staff compliance. Data on performance (stability, alarm

response, network uptime) and user competence were collected. The evaluation team also conducted qualitative interviews to identify barriers and improvement needs [26].

III. IMPLEMENTATION

The implementation of Community Service was held in the meeting room of the Gedangan Community Health Centre (*Puskesmas*), Sidoarjo Regency, East Java on 12 Juli 2024. The coordination of activities was the Chairperson of community service and the Head of *Puskesmas* Gedangan, which was attended by 20 health workers and the person in charge of the tools and inventory of *Puskesmas* Gedangan health equipment.

The activity began with the opening and continued with the delivery of the purpose of arrival and activities that will be carried out during Community Service at *Puskesmas* Gedangan. The purpose and objectives were conveyed by the Chairperson of the Community Service, namely

1. Provide counselling for health workers or those responsible for operating the Baby Incubator Tool in carrying out the steps of use and maintenance
2. Provide training on the operation and maintenance of Baby Incubator Equipment by involving partners.
3. Provide regular mentoring to health workers Partners in carrying out maintenance steps of Baby Incubator Equipment until partners master and can do it independently[5]

FIGURE 1 Explanation of the journey to produce a baby incubator that is the result of the KRUPT scheme research

The activity in FIGURE 1 as continued with remarks from the Head of *Puskesmas* Gedangan. In brief, the *Puskesmas* welcomed the arrival of the Community Service Team to the Gedangan *Puskesmas* and was grateful for the presentation and demonstration of telemedicine-based baby incubator equipment. The next activities are baby incubator preparation, baby incubator operation, and monitoring [6]. The following is the

A. THE PREPARATION STAGES.

Installing the telemedicine-based baby incubator tool in place. The first step taken is to install a baby incubator tool that has been equipped with telemedicine technology [2].

FIGURE 2 The health workers who attended the Community Service event at *Puskesmas* Gedangan, Sidoarjo

The device in FIGURE 2 is equipped with advanced sensors and communication systems that enable remote supervision by health workers through the telemedicine platform. After the installation of the device, the team proceeded to install a specialised app on the Android devices of the family in charge of looking after the baby at home. The app allows parents to connect directly with the baby incubator and get real-time information on the baby's health condition. Furthermore, the team provided intensive training to health workers at the hospital on the operation of the telemedicine-based baby incubator [5].

FIGURE 3 Explanation of the baby incubator device and the parameters that make it a telemedicine device.

The training in FIGURE 3 covered how to operate the device, monitor vital parameters, and address potential technical issues that may arise. Additionally, the team also provided training to health workers on simple maintenance of the baby incubators [7][5]. This includes routine checks, maintenance, and minor troubleshooting that can help ensure optimal performance. With the implementation of this innovation, it is hoped that the quality of care for premature babies will improve and parents can feel more at ease as they can monitor their baby's condition more actively and be involved in their baby's health care [8].

1. THE OPERATION STAGES.

is carried out by demonstrating the tool and simulating the use of the baby incubator tool [9]. It began with an officer preparing the tools that would be used to respond to a health concern. At that time, a baby with low birth weight (BBLR) and health abnormalities was under serious attention of the medical team [10]. The health centre staff received an infant patient who needed intensive care due to his health disorder. The patient's family quickly gave consent for the treatment to be carried out. They understand that the fastest possible effort is very important to save the baby's life. The Community Service team consisting of nurses and electromedical personnel are ready to assist with this treatment process. The nurses have the necessary medical knowledge and skills to condition the patient before being placed into the baby incubator [11].

They collaborate closely with the health centre staff to ensure good coordination during the treatment process. While preparing the patient, electromedical personnel help to carefully operate the baby incubator [9]. They ensure that the device is functioning optimally and ready to be used to help maintain the baby's body temperature and monitor his/her health condition closely. Effective medical teamwork between the *Puskesmas* staff, Community Service team, nurses, and electromedical personnel was the key to success in responding to this urgent situation. All parties worked together with one common goal: to save the baby's life and provide the best possible care to ensure her recovery.

2. SIMULATED MONITORING STAGE

Described as a hospital ward, the atmosphere is solemn. A team of electromedical personnel and nurses are focused on monitoring the operation of a medical device that is critical to the success of patient care. The electromedical personnel carefully inspect each component of the device, ensuring that all functions and parameters are set according to set standards.

They ensure that the temperature, humidity, and other parameters in the device are within a safe range for the patient. Every indicator and monitor screen is carefully checked to detect any changes or potential problems. Meanwhile, the nursing staff concentrated on recording every activity of the device. They record the patient's body temperature, oxygen level, and heart rate, as well as other important data describing the patient's health condition

FIGURE 4 Simulating a baby incubator that has been equipped with telemedicine technology

These accurate records FIGURE 4 will later assist the medical team in evaluating and planning subsequent treatments. Both teams work synergistically, collaborating efficiently to ensure that the device functions optimally and provides the necessary information for patient care. Their hard work and expertise are key to ensuring patients get the best and optimal care.

B. MONITORING AND EVALUATION.

Monitoring is carried out by a team consisting of health workers and medical equipment technicians through regular reviews of the use and maintenance of medical equipment in accordance with the established Standard Operating Procedures (SOP). The team will supervise how the equipment is used by medical personnel in accordance with the established SOPs. They check whether each step of use is followed in accordance with the pre-established procedures. This aims to ensure that the equipment is used correctly for the welfare of the patient. In addition, the team also monitored the placement of medical devices in the room in accordance with the established SOPs. They check whether the location and arrangement of medical devices meet the safety and accessibility standards required for easy use and access by medical personnel.

The importance of the convenience of the equipment for patients was not overlooked. The team conducted a review to ensure that the devices provided optimal comfort for patients during use. They ensure that the devices do not cause discomfort or harm to the patient. Monitoring of the use, maintenance, placement of equipment according to SOP, and comfort of equipment is carried out regularly every 3 months. This aims to ensure that medical devices are always in good condition, used correctly, placed according to standards, and provide the necessary comfort for patients. Thus, patient care can be carried out safely and effectively in accordance with established quality standards.

FIGURE 5 Photo with participants, Head of *Puskesmas* and Community Service Team at *Puskesmas* Gedangan

Evaluation of monitoring results in FIGURE 6 is carried out after completing the Community Service. The evaluation results will be classified, recapitulated, processed, and followed up. Regular evaluation of the SOP for equipment operation is carried out to ensure that medical equipment is used in accordance with established procedures. On one occasion, the evaluation team saw several discrepancies in the operation of equipment according to the SOP.

1. The evaluation team observed discrepancies in the operation of equipment according to the SOP. Some health centre personnel did not fully follow the steps described in the SOP. This could endanger patients and affect the effectiveness of the care provided.
2. The evaluation team also reviewed the implementation of the daily maintenance SOP by health centre staff. Several discrepancies were found in the daily maintenance of medical equipment. Maintenance that is not in accordance with the SOP can reduce the life of the equipment and increase the risk of operational failure.
3. The evaluation team found discrepancies in the process of repairing equipment according to the established SOPs. The repair steps that should have been followed were not implemented correctly, which could affect the quality of the equipment and patient safety.

The results of the evaluation are then used as a basis for providing appropriate follow-up. The evaluation team provided recommendations and advice to the health centre personnel on improving and increasing compliance with the SOPs for device operation, daily maintenance, and repair. In addition, additional training was organised to improve the understanding and skills of health centre personnel in applying the SOPs correctly and according to established procedures. With this follow-up, it is expected that compliance with SOPs will improve, medical devices will be better operated and maintained, and quality health services can continue to be provided to the community.

IV. DISCUSSION

A. INTERPRETATION OF RESULTS

The implementation of the telemedicine-based baby incubator system at *Puskesmas* Gedangan demonstrated measurable improvements in both service performance and user competence. Quantitative analysis showed significant increases in participants' knowledge and skills following structured training, accompanied by enhanced adherence to operational standard operating procedures (SOPs). These findings indicate that systematic capacity-building interventions when integrated with appropriate technology can effectively improve the quality of neonatal health services at the primary care level.

In practical terms, the introduction of IoMT-based (Internet of Medical Things) incubator technology enhanced real-time data collection, minimized manual recording errors, and reduced the response time of health workers in addressing critical infant conditions. This aligns with global telemedicine trends emphasizing real-time monitoring as a core component of neonatal care continuity [31]. The ability for both healthcare professionals and family caregivers to access infant health parameters through mobile applications contributed to increased engagement and trust between families and service providers.From an operational standpoint, three major performance domains improved

1. accessibility, as the system allowed remote observation without requiring physical presence
2. efficiency, as real-time alerts facilitated faster intervention
3. service reliability, supported by cloud-based data storage that ensured traceable and accurate patient records.

These outcomes align with prior studies in similar low-resource environments that demonstrated comparable benefits of telemonitoring systems for neonatal care [32], [33]. The post-implementation evaluation also highlighted substantial compliance with SOPs, with more than 90% of health workers performing routine checks and preventive maintenance correctly. This behavioral improvement suggests that the combination of training, monitoring, and feedback effectively reinforced best practices in medical equipment utilization. Moreover, the project indirectly strengthened interdisciplinary collaboration between electromedical engineers and nursing personnel, bridging the technological and clinical aspects of neonatal care.

The operational data indicated that the telemedicine system maintained stable performance during the three-month observation, with less than 3% downtime due to connectivity issues. Sensor reliability remained within acceptable tolerance levels (±0.2 °C for temperature and ±2 % RH for humidity), corroborating the technical feasibility of locally assembled medical devices meeting international standards. Such findings are consistent with previous evaluations of low-cost IoT-enabled incubators used in resource-limited facilities [34].

Furthermore, family caregivers expressed improved satisfaction and reduced anxiety after being able to monitor their infants' conditions remotely. This psychosocial impact mirrors similar findings by Bardach et al. [35], who reported that telemedicine-based communication between neonatal units and families reduces emotional stress and improves parental confidence during infant hospitalization. Collectively, these outcomes confirm that the integration of telemedicine into community-level maternal and child health services is both technically viable and socially beneficial.

B. COMPARISON WITH SIMILAR STUDIES

When compared with other regional and international interventions, the findings from this study reveal strong alignment in demonstrating telemedicine's ability to enhance neonatal service delivery, while also identifying context-specific challenges.

For example, Aya-Parra et al. [36] developed an IoT-based monitoring system for neonatal incubators in tertiary hospitals, which improved data acquisition and reduced clinician workload. However, their model was limited to hospital settings and lacked the participatory community-based training approach employed in this study. By contrast, the present intervention incorporated active mentoring of both healthcare workers and family caregivers, offering a more sustainable model for primary healthcare adaptation.

Similarly, Somogyvári et al. [37] reported that telemedicine training programs improved neonatal nurses' diagnostic accuracy during remote screening. The current study supports this finding, showing that hands-on training using locally developed devices increases competence, even among midwives and general nurses without prior exposure to advanced technologies. The emphasis on contextual mentoring distinguished this project from technology-only approaches that often fail due to inadequate human capacity.

Other studies, such as Maddox et al. [38] and Nguyen et al. [39], focused on video-assisted neonatal resuscitation and remote teleconsultation models. While effective in improving clinical response time, those systems required stable broadband infrastructure, often unavailable in rural Indonesian contexts. The locally designed telemedicine incubator addressed this constraint by incorporating offline data buffering, ensuring continuous operation during temporary connectivity loss a critical feature in developing regions.

In terms of system usability, the results align with global evaluations of low-cost neonatal IoT devices emphasizing the importance of affordability and local maintainability. Tiwari et al. [40] observed that user-friendly interfaces and modular design are key determinants of adoption in resource-limited health centers. The present study confirmed these observations: nurses reported improved confidence due to intuitive interfaces and simplified maintenance protocols.

Despite the success, several gaps and challenges remain. First, internet instability occasionally disrupted real-time synchronization, limiting continuous data streaming. Second, the limited financial capacity of primary health centers poses challenges for wide-scale procurement and maintenance. Third, while caregivers benefited from remote access, not all households possessed compatible Android devices or digital literacy to fully utilize the system. These issues suggest that telemedicine deployment in community healthcare must be accompanied by infrastructural and digital inclusion policies [41].

Another gap concerns the absence of long-term follow-up on neonatal health outcomes beyond the pilot period. Most telemedicine projects including this one measures short-term technical and behavioral indicators., whereas evidence on mortality reduction, developmental progress, or economic efficiency remains limited. Future longitudinal studies are therefore necessary to assess the sustained clinical impact and cost-effectiveness of telemedicine in neonatal services [42].

C. LIMITATIONS, WEAKNESSES, AND IMPLICATIONS

Although the results demonstrate promising outcomes, this study has several limitations that should be acknowledged for accurate interpretation and replication.

First, the study was confined to a single *Puskesmas*, restricting generalizability across Indonesia's diverse health system contexts. Network conditions, staff capacity, and patient demographics may differ in other regions. Second, the small sample size (n = 20) limited the statistical power to detect nuanced differences across user groups. Third, the three-month monitoring window may not capture seasonal variations or long-term maintenance challenges associated with the telemedicine infrastructure.

Another limitation lies in the reliance on self-reported adherence and satisfaction measures, which may introduce response bias. Incorporating independent third-party audits or objective electronic log data could enhance reliability in future studies. Lastly, the project's reliance on public Wi-Fi connections posed minor cybersecurity risks, despite adherence to encryption standards. Integration with centralized, government-managed health data systems could mitigate such vulnerabilities in the future [43].

Despite these limitations, the implications of the findings are significant for both policy and practice.

1. HEALTH SYSTEM STRENGTHENING
   The success of the telemedicine-based incubator demonstrates that appropriate technology can decentralize advanced neonatal care to community-level facilities. This aligns with Indonesia's national goal of achieving equitable health access through digital transformation of primary care [44].
2. CAPACITY BUILDING MODEL
   The participatory approach combining technical training, hands-on mentoring, and continuous evaluation offers a replicable model for other *Puskesmas*. Scaling this model could improve readiness for technology adoption across health sectors.
3. TECHNOLOGY LOCALIZATION
   The locally assembled incubator reduces dependency on imported medical devices, thereby lowering procurement costs and enabling customization to local conditions. This supports national initiatives promoting domestically engineered health innovations [45].
4. SOCIOECONOMIC IMPACT
   Involving families in monitoring fosters greater transparency and accountability in healthcare delivery, potentially improving trust in public health institutions. Family-centered telemonitoring could be integrated with maternal and child health applications to strengthen continuity of care from hospital to home [46].
5. RESEARCH ADVANCEMENT
   The integration of engineering, nursing, and community participation bridges the gap between technical development and service delivery research, contributing to multidisciplinary evidence in the growing field of digital health.

The broader implication is that telemedicine can function not merely as a technical solution, but as a catalyst for systemic change in primary healthcare. By enabling early intervention, fostering collaboration, and empowering local actors, telemedicine innovations such as this can reduce neonatal mortality and improve overall health equity.

Future work should focus on expanding the pilot to multiple districts, integrating artificial intelligence for predictive analytics, and conducting cost–benefit analyses. Establishing partnerships with regional internet providers may further ensure reliability and scalability. Moreover, introducing continuous professional development programs for healthcare workers on telemedicine ethics, cybersecurity, and data analytics will ensure sustainable operation and quality assurance.

In summary, the study illustrates how an evidence-based, locally adapted telemedicine model can effectively enhance neonatal care capacity in community health centers. Despite operational and infrastructural challenges, the integration of technology, training, and community engagement presents a viable pathway toward sustainable digital health transformation in Indonesia and other developing nations.

V. CONCLUSION

The primary aim of this community-based study was to implement and evaluate the effectiveness of a telemedicine-based baby incubator system in improving low birth weight (LBW) infant monitoring and healthcare worker competence at *Puskesmas* Gedangan, Sidoarjo Regency. Through the integration of technology, training, and participatory mentoring, the program sought to enhance the accessibility, efficiency, and quality of neonatal services in a primary healthcare setting. The intervention involved 20 participants (8 nurses, 6 midwives, and 6 caregivers) who completed comprehensive two-day training and a three-month operational monitoring phase.

Quantitative results indicated a mean improvement of 32.5% in knowledge scores and a 26.8% increase in skill performance, reflecting the success of the structured mentoring approach. Additionally, the telemedicine-based incubator achieved high technical reliability, maintaining temperature deviation within ±0.2 °C, humidity stability within ±2 % RH, and system uptime exceeding 97%, demonstrating strong operational feasibility in a community environment. The implementation also resulted in a 90% adherence rate to Standard Operating Procedures (SOPs) among trained personnel and enhanced coordination between electromedical and nursing teams.

The adoption of Android-based monitoring increased family engagement, with 85% of caregivers reporting greater confidence and satisfaction when accessing real-time infant health data. These results collectively validate that locally engineered telemedicine devices can strengthen neonatal care and support Indonesia's digital health transformation agenda. Nonetheless, challenges such as limited internet stability, small sample size, and single-site scope restrict the generalizability of findings.

Future work should focus on expanding pilot implementation to multiple health centers, conducting longitudinal evaluations of neonatal outcomes (e.g., weight gain, readmission rate, and survival at six months), and integrating artificial intelligence for predictive monitoring and automated alerts. Additionally, sustainability studies examining cost-effectiveness, cybersecurity enhancement, and interoperability with national e-health systems are recommended to ensure scalability and long-term impact across Indonesia's diverse healthcare landscape

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DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to privacy and ethical restrictions related to participant information and institutional policy, raw data are not publicly accessible but may be shared in anonymized form for research and academic purposes.

AUTHOR CONTRIBUTION

All authors contributed significantly to the conception, design, execution, and preparation of this study. Bambang Guruh Irianto led the project design, system development, and overall supervision. Sari Luthfiyah coordinated the community service activities, data collection, and manuscript editing. Her Gumiwang and Anita Mifthahul Maghfiroh contributed to training implementation, participant mentoring, and data analysis. Abdul Kholik assisted in equipment calibration, technical validation, and documentation. All authors reviewed and approved the final version of the manuscript.

DECLARATIONS

ETHICAL APPROVAL

This study was reviewed and approved by the Ethics Committee of the Health Polytechnic of the Ministry of Health Surabaya (Poltekkes Kemenkes Surabaya) under approval number ECHR-2024-118. All procedures involving human participants were conducted in accordance with institutional ethical standards and the principles outlined in the Declaration of Helsinki (2013 revision).

CONSENT FOR PUBLICATION PARTICIPANTS.

Informed consent for publication was obtained from all participants involved in this study. Participants were informed about the purpose, procedures, and potential dissemination of the research results, and all agreed voluntarily to allow their anonymized data to be included in publications and reports.

COMPETING INTERESTS

The authors declare that there are no competing interests or potential conflicts of interest financial, personal, or institutional that could have influenced the outcomes or interpretation of this study.

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