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Telemedicine-Enabled Bedside Monitoring System for Low-Birth-Weight Infants: Strengthening Primary Healthcare Resilience and Family-Centered Neonatal Care in Indonesia

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ABSTRACT Low Birth Weight (LBW) infants remain highly vulnerable to respiratory instability, temperature disturbances, infection, and other complications, making continuous physiological monitoring essential. However, primary healthcare facilities may face limitations in access to real-time monitoring technology, remote information sharing, and health-worker competency in operating and maintaining digital medical devices. This community service activity aimed to implement a telemedicine-based bedside monitoring system at Gedangan Community Health Center, Sidoarjo Regency, while strengthening health workers' knowledge, operational skills, and compliance with standard operating procedures (SOPs) for LBW neonatal monitoring. The program was conducted over two days and involved 30 health workers, including nurses, midwives, and electromedical personnel. The implementation comprised counseling, expert demonstration, hands-on training, simulation, re-demonstration, evaluation, and continuing mentoring. Knowledge was assessed through pre- and post-training questioning, while practical competence and SOP adherence were evaluated through structured observation. The mean knowledge score increased from 62.4% before training to 86.7% after training, representing a 24.3-percentage-point improvement. Furthermore, 83% of participants were able to operate the bedside monitor independently, while SOP compliance increased from 54% during initial practice to 88% after training. The system also successfully transmitted physiological parameters, including oxygen saturation, heart rate, respiratory rate, and temperature, to both the bedside monitor and mobile application without significant transmission delay during simulation and initial field use. In addition, four medical devices at the health center were repaired and calibrated. The findings demonstrate that integrating telemedicine-based monitoring with structured practical training can strengthen neonatal monitoring capacity and improve access to physiological information at the primary healthcare level. Nevertheless, sustained mentoring, periodic refresher training, reliable connectivity, and dedicated maintenance resources remain necessary to ensure long-term safety, compliance, and system sustainability.

INDEX TERMS Low Birth Weight, Telemedicine, Bedside Monitoring, Neonatal Care, Primary Healthcare

I. INTRODUCTION

Low Birth Weight (LBW) remains an important neonatal health problem because affected infants are more susceptible to respiratory instability, temperature disturbances, infection, feeding difficulties, and other complications requiring continuous physiological observation [1]–[4]. Recent evidence from Indonesia also demonstrates that LBW remains strongly associated with neonatal mortality and poor survival outcomes, emphasizing the need for timely monitoring and appropriate clinical management [2]. In primary healthcare settings, the challenge is particularly important because continuous access to advanced neonatal monitoring and technical expertise may be more limited than in referral hospitals. At the Gedangan Community Health Center,

Sidoarjo Regency, preliminary assessment identified limitations in continuous physiological monitoring, restricted remote access to patient information, and the need to strengthen health workers' technical competence in operating, maintaining, and troubleshooting digital medical equipment. These conditions may reduce the effectiveness and continuity of neonatal monitoring, particularly for infants requiring close observation.

Digital health and telemedicine have increasingly been recognized as important approaches for strengthening primary healthcare services by improving access to health information, supporting communication, and enabling remote monitoring [5]–[8]. The World Health Organization has emphasized digital transformation as an important component of resilient primary healthcare,

particularly through technologies that improve information availability and service delivery [9], [10]. In neonatal care, telemedicine can extend the accessibility of physiological information beyond the immediate bedside and facilitate communication between healthcare personnel and families. Recent studies have also highlighted the potential of family-centered care to improve parental participation, experience, and mental health during neonatal hospitalization [11], [12]. Accordingly, integrating telemedicine with bedside monitoring provides an opportunity to connect physiological measurement, remote information access, and family participation within a single healthcare framework.

The state of the art in this area includes remote patient monitoring, telemedicine-enabled neonatal care, mobile health applications, and connected medical devices capable of transmitting physiological parameters [5], [7], [13]–[15]. Previous work by Irianto et al. demonstrated the development and application of telemedicine-based neonatal monitoring technologies, including integration with infant incubators and physiological signal processing [13], [14]. However, technological availability alone does not guarantee effective implementation. Successful digital-health adoption also depends on healthcare workers' competencies, usability, adherence to operational procedures, maintenance capability, and organizational support [8], [16]–[18]. Experiential learning, simulation, demonstration, and repeated hands-on practice have been reported as effective approaches for developing practical competencies among healthcare personnel [19]–[21].

Despite these developments, a practical gap remains in translating telemedicine-based neonatal monitoring technology into sustainable primary healthcare practice. Existing studies frequently emphasize technological development or clinical functionality, whereas less attention is given to the combined implementation of technology, health-worker competency development, SOP compliance, equipment maintenance, and continuing mentoring within a community health-center environment. The present activity addresses this gap by combining implementation of a telemedicine-based bedside monitor with structured education, hands-on practice, simulation, re-demonstration, and periodic follow-up. This approach is particularly relevant because post-implementation monitoring in the present study identified non-compliance related to equipment operation, daily maintenance, and repair procedures [22].

Therefore, this community service activity aimed to implement a telemedicine-based bedside monitoring system at Gedangan Community Health Center, Sidoarjo Regency, while improving health workers' knowledge, practical competence, and adherence to SOPs for neonatal monitoring. The specific contributions of this work are threefold: (1) implementation of a telemedicine-enabled bedside monitoring system capable of providing real-time physiological information for LBW infants; (2) evaluation of the effectiveness of structured counseling, demonstration, simulation, and re-demonstration in improving health-worker knowledge and operational competency; and (3) identification of operational and maintenance challenges and formulation of continuing

mentoring and equipment-management strategies to support sustainable implementation. The article is organized as follows: Section II describes the methods and implementation procedures; Section III presents the results of training, monitoring, evaluation, and equipment-support activities; Section IV discusses the findings, implementation challenges, implications, and limitations; and Section V concludes the study and provides recommendations for future implementation.

II. METHODS

A. STUDY DESIGN AND PARTICIPANT

This community service activity employed a prospective, single-group pretest–posttest intervention design to evaluate the implementation of a telemedicine-based bedside monitoring system and its associated training program at the Gedangan Community Health Center, Sidoarjo Regency, East Java, Indonesia. The activity was conducted on May 6–7, 2026, in the meeting hall of the Gedangan Community Health Center. The design was selected because the primary objective was to implement the monitoring technology while assessing changes in participants' knowledge, practical competency, and adherence to standard operating procedures (SOPs) before and after structured training. The activity did not employ randomization or a control group because all personnel involved in the relevant neonatal monitoring and medical-equipment management activities were included as program participants. The use of a prospective implementation approach enabled the training process, participant performance, and operational outcomes to be documented sequentially.

The target population comprised healthcare personnel at the Gedangan Community Health Center who were involved in neonatal care and/or medical-equipment management. A total of 30 participants were included, consisting of nurses, midwives, and electromedical personnel responsible for clinical monitoring, medical equipment operation, and equipment maintenance. The participants were selected purposively according to their institutional roles and relevance to the use and management of the telemedicine-based bedside monitor. No individual randomization was performed. The multidisciplinary composition of the participants was intended to ensure that both clinical and technical aspects of the monitoring system could be addressed during implementation.

B. MATERIALS AND EQUIPMENT

The principal intervention equipment was a Telemedicine-based Infant Bedside Monitor designed to support physiological monitoring of LBW infants. The device was configured to monitor skin temperature, respiratory rate, peripheral oxygen saturation (SpO₂), heart rate (BPM), non-invasive blood pressure (NIBP), and electrocardiographic (ECG) activity. The telemedicine component enabled physiological data obtained from the bedside monitor to be transmitted through a network connection and displayed on a dedicated Android-based mobile application. This configuration was used to demonstrate remote access to physiological information for healthcare personnel and families.

Supporting materials consisted of an LCD projector, PowerPoint presentations, training materials, operational instructions, sensor accessories, the Android mobile application, and equipment operating and maintenance procedures. The instructional materials covered the principles of LBW monitoring, the function of each monitored parameter, sensor placement, device activation, parameter configuration, telemedicine application pairing, interpretation of displayed physiological data, routine maintenance, and basic troubleshooting. The use of connected monitoring technologies is consistent with recent approaches to remote monitoring in primary healthcare, in which physiological information can be electronically acquired, transmitted, and accessed remotely by healthcare personnel [23], [24].

C. ACTIVITY PROCEDURE

The implementation procedure consisted of three principal stages: preparation, implementation, and evaluation and reporting. The overall sequence of activities is presented in Figure 1. The preparation stage involved identification of mentoring needs, determination of the training materials and participant group, and preparation of instructional media and equipment. The implementation stage consisted of theoretical presentation, expert demonstration, practical simulation, and participant re-demonstration. The final stage involved evaluation of knowledge and practical competency, documentation of findings, and preparation of the activity report. FIGURE 1 illustrates the systematic flow used to organize these activities from preparation through implementation, evaluation, and reporting.

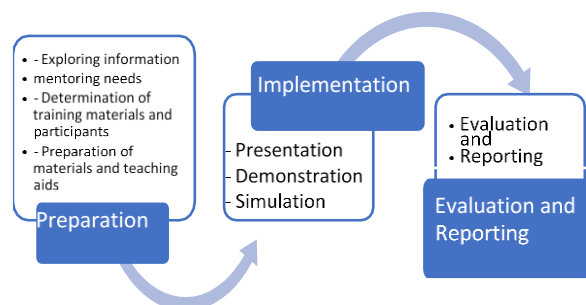


FIGURE 1. Flow Activity Implementation

During the first stage of implementation, participants received structured counseling concerning LBW, the importance of continuous physiological monitoring, the function of each parameter measured by the bedside monitor, and the role of telemedicine in extending access to monitoring information. The instructional presentation was delivered using an LCD projector and PowerPoint materials. Theoretical instruction was followed by an expert-led demonstration of the equipment. Demonstration procedures included device activation, correct sensor placement, selection and configuration of monitoring parameters, interpretation of displayed values, connection of the bedside monitor to the Android application, and demonstration of remote physiological-data transmission.

The practical component then proceeded to simulation and re-demonstration. Participants were required to perform the operational procedures previously demonstrated by the training team. Each participant

practiced the sequence of device preparation, sensor application, parameter configuration, monitoring, and mobile-application synchronization under supervision. Simulation was incorporated to provide an opportunity for participants to apply technical procedures in a controlled environment before independent operation. Recent evidence indicates that simulation and authentic learning can support the development of cognitive and psychomotor competencies among healthcare learners and personnel [25], [26]. Repeated practice accompanied by immediate feedback was used to identify procedural errors and allow participants to repeat the relevant procedure until an acceptable level of performance was achieved. This approach is consistent with simulation-based training models emphasizing deliberate practice and feedback to improve technical and non-technical competencies [27].

D. EVALUATION PROCEDURES

Knowledge evaluation was performed using direct oral questioning before and after the training intervention. The questions were developed by the academic and technical team and addressed the principles of LBW monitoring, functions of the monitored physiological parameters, interpretation of vital-sign measurements, telemedicine integration, and essential equipment-operation procedures. Responses were assessed directly by the evaluators based on conceptual accuracy and understanding. The pre-training and post-training results were subsequently compared to identify changes in participant knowledge.

Practical competency was assessed during demonstration and re-demonstration using a structured observation checklist. The checklist covered device activation, sensor placement, parameter configuration, operation of the bedside monitor, mobile-application synchronization, interpretation of displayed information, and adherence to SOPs. Performance was classified into three categories: independent and correct performance, partially assisted performance, and incorrect or incomplete performance. Participants who did not perform a procedure correctly received direct corrective feedback and repeated the procedure under supervision.

The evaluation also included observation of the telemedicine transmission process during simulation and initial field application. Successful operation was determined from the ability of the system to display physiological parameters on both the bedside monitor and the connected mobile application. In addition, technical support activities included inspection, repair, and calibration of available medical equipment at the health center. These activities were documented as part of the broader equipment-management component of the community service program.

E. DATA ANALYSIS AND OUTCOME MEASURES

The primary outcome measures were the change in participants' knowledge between pre-training and post-training assessments, the proportion of participants able to operate the bedside monitor independently, and the level of SOP compliance during practical assessment. Descriptive analysis was used to summarize participant performance and operational outcomes. Knowledge improvement was

expressed by comparing the mean percentage scores obtained before and after training. Practical competency was reported as the percentage of participants within each performance category, while SOP adherence was expressed as the proportion of observed procedures performed according to the established operational requirements. The resulting quantitative and qualitative observations were synthesized to determine the effectiveness of the implementation and to identify areas requiring further mentoring.

The methodological approach also incorporated continuing mentoring because telemedicine implementation requires not only initial deployment but also appropriate operational, maintenance, and organizational support [23], [24]. The World Health Organization similarly emphasizes planning, implementation, monitoring, and maintenance as essential components of sustainable telemedicine services [23]. Accordingly, the program included recommendations for periodic refresher training and follow-up supervision to maintain operational competency and support safe and sustainable utilization of the bedside monitoring system.

III. RESULTS

Community service activities were systematically executed on a scheduled basis over two consecutive days, May 6-7, 2026, within the premises of the Gedangan Health Center meeting hall, Sidoarjo Regency. The implementation was meticulously structured into several sequential, pedagogical stages to ensure optimal knowledge transfer and skill acquisition: a formal opening, theoretical material provision, intensive operational training, high-fidelity simulation, and comprehensive evaluation. This structured approach was designed to transition the participants from theoretical understanding to practical competence seamlessly.

The activity commenced with a formal opening ceremony, establishing a collaborative and respectful tone between the academic institution and the primary healthcare facility. **FIGURE 2** is the session was inaugurated with a comprehensive address by the Head of the Community Service Team, Prof. Dr. Ir. Bambang Guruh Irianto. In his remarks, he articulated the core intent and purpose of the initiative, emphasizing the critical need to bridge the technological gap in neonatal care at the primary healthcare level.



FIGURE 2. Opening Speech by the Head of the Gedangan Health Center, dr. Irawati

Furthermore, **FIGURE 3** Prof. Irianto provided an extensive explanation regarding the origins of the

equipment, detailing the rigorous research and development process that led to the creation of the Infant Bedside Monitor under the Applied Product Research (PPUPT) scheme. This contextualization was vital, as it validated the scientific credibility of the device and reassured the health center staff of its efficacy and safety standards.



FIGURE 4. Explanation of the Process of Producing the Infant Bedside Monitor from the PPUPT Research Scheme by Bambang Guruh Irianto

The ceremonial segment concluded with an official speech by the Head of the Gedangan Health Center, dr. Irawati. On behalf of the institution, she expressed profound gratitude and formally welcomed the Community Service Team. Dr. Irawati underscored the strategic relevance of the telemedicine-based infant Bedside Monitor, acknowledging that its presentation and demonstration would significantly enhance the health center's capacity to manage vulnerable neonates and provide reassurance to anxious families.

Following the formalities, the program transitioned into the core educational phase. **FIGURE 4**, the academic team provided an exhaustive explanation of the Telemedicine-based Infant Bedside Monitor, deconstructing its complex architecture into comprehensible modules. The instruction covered the physiological relevance of each monitoring parameter—skin temperature, respiration rate, SPO₂, BPM, NIBP, and ECG—and how these metrics correlate with the clinical stability of LBW infants [28].

A significant portion of the training was dedicated to the telemedicine infrastructure. **FIGURE 6** the team demonstrated the procedural protocols for installing the device and subsequently configuring the dedicated application on the Android devices of the families assigned to care for the baby at home. This segment illuminated how the application establishes a secure, encrypted connection with the Bedside Monitor, thereby granting parents the unprecedented ability to access real-time, continuous data regarding their infant's health status remotely [23][26][28].

Intensive, hands-on training was then facilitated for the health workers. This practical session was meticulously designed to cover the entire operational lifecycle of the device, encompassing correct initialization, precise sensor placement on neonatal anatomy, alarm threshold configuration, and continuous monitoring of critical parameters. Furthermore, **FIGURE 5**, acknowledging that technological devices in clinical settings are prone to operational wear, the team incorporated modules on basic troubleshooting and preventive maintenance. Participants

were trained to identify common technical anomalies, perform rudimentary software resets, and execute daily hardware maintenance routines to ensure the device's operational longevity [29][30][31].



FIGURE 5. Explanation of the Bedside Monitor Device and its Telemedicine Parameters

Simulation and Monitoring Stage To solidify the theoretical and practical knowledge acquired during the training, a high-fidelity simulation stage was conducted. The meeting hall was transformed to accurately replicate the dynamic environment of a neonatal hospital ward. This immersive scenario was designed to test the participants' ability to operate the medical device under simulated clinical pressures while fostering interprofessional collaboration [32].



FIGURE 6. Installation of the Infant Bedside Monitor Equipped with Telemedicine Technology



FIGURE 7. Simulation of the Infant Bedside Monitor Equipped with Telemedicine Technology

FIGURE 7, a dedicated team comprising electromedical personnel and nursing staff was assembled to focus on the comprehensive monitoring of the medical device's operation. The simulation required a symbiotic division of labor. The electromedical personnel assumed

responsibility for the technological integrity of the apparatus. They meticulously checked each hardware component, verified sensor connectivity, and ensured that all functional parameters and alarm limits were configured strictly in accordance with established clinical standards (temperature, humidity, SPO2, BPM). Their primary objective was to guarantee that the data transmission to the telemedicine application was seamless and artifact-free [33][26].

Concurrently, the nursing staff concentrated on the clinical interpretation of the generated data. They practiced continuously monitoring the displays, recording the infant's physiological trends, and documenting every activity and output of the device. This exercise emphasized the critical nature of accurate clinical documentation, which serves as the foundational legal and medical record for evaluating the infant's progress and planning subsequent care. The simulation successfully demonstrated the synergistic potential of the technology; the electromedical team ensured the precision of the data capture, while the nursing team ensured that the data was translated into actionable clinical insights, thereby embodying a holistic approach to technology-enabled neonatal care [34].

IV. DISCUSSION

A. IMPROVEMENT IN KNOWLEDGE, PRACTICAL SKILLS, AND COMPLIANCE WITH STANDARD OPERATING PROCEDURES

The implementation of the Telemedicine-based Bedside Monitor at the Gedangan Health Center demonstrated a positive improvement in the knowledge and practical competence of healthcare workers involved in the monitoring of Low Birth Weight (LBW) infants. The mean pre-test score increased from 62.4% to 86.7% after the intervention, representing an improvement of 24.3 percentage points. This finding indicates that the combination of theoretical counseling, expert demonstration, hands-on practice, re-demonstration, and immediate feedback was effective in strengthening participants' understanding of neonatal monitoring and telemedicine-based equipment operation. The improvement was not limited to theoretical knowledge, but was also reflected in practical performance, as 83% of participants were able to operate the bedside monitor independently, whereas 17% still required partial assistance, particularly during sensor placement and mobile application synchronization.

The improvement in learning outcomes is consistent with previous evidence concerning the effectiveness of structured educational interventions for digital healthcare competencies. Kulju et al. reported that multi-method educational interventions combining theoretical instruction with practical activities can improve knowledge, technical skills, attitudes, and confidence among healthcare professionals using digital technologies [35]. Similarly, Longhini et al. emphasized that digital health competency involves not only knowledge of technology but also the ability to use digital systems appropriately in clinical practice [36]. Therefore, the present findings suggest that the training approach used at the Gedangan Health Center

was appropriate because participants were not only introduced to the functions of the equipment but were also required to demonstrate the operational procedures independently.

The use of practical simulation was particularly important because the Telemedicine-based Bedside Monitor requires coordination between clinical interpretation and technical operation. The training involved device activation, sensor placement, parameter configuration, monitoring, mobile application synchronization, and troubleshooting. This approach provided participants with an opportunity to translate theoretical knowledge into procedural competence. Evidence from systematic reviews of healthcare simulation similarly indicates that simulation-based education can support the development of technical and clinical skills, particularly when participants receive opportunities to practice procedures in realistic contexts [37], [38]. The findings therefore support the use of re-demonstration and simulation as complementary components of training for medical equipment that requires both psychomotor and cognitive competencies.

The increase in SOP compliance provides additional evidence of the benefit of the intervention. Compliance with appropriate operational procedures increased from an initial observation of approximately 54% to 88% after training. This improvement is important because correct operation of medical equipment cannot be evaluated solely from the ability to switch on and operate the device. Correct sensor placement, appropriate parameter configuration, adherence to alarm settings, routine maintenance, and proper troubleshooting are all essential to maintain measurement reliability and patient safety. The observed improvement therefore indicates that the intervention contributed to greater procedural standardization among healthcare workers.

However, the finding that 17% of participants still required assistance should not be interpreted as a failure of the program. Rather, it demonstrates that competency acquisition was not uniform across all participants. Procedures involving sensor placement and application synchronization require coordination between physical equipment and digital infrastructure, which may require repeated practice. This finding is consistent with the broader literature indicating that digital health competency is multidimensional and that continuing education is necessary to maintain and develop practical skills [35], [36]. Consequently, the three-month monitoring and additional training recommended by the program are important mechanisms for reinforcing competency after the initial intervention.

B. TELEMEDICINE INTEGRATION, MEDICAL EQUIPMENT SUPPORT, AND IMPLICATIONS FOR FAMILY-CENTERED NEONATAL CARE

The implementation of the Telemedicine-based Bedside Monitor provided an additional dimension to neonatal monitoring by enabling physiological parameters to be observed through both the bedside monitor and a mobile application. The system was designed to monitor skin temperature, respiratory rate, peripheral oxygen saturation

(SpO₂), heart rate, non-invasive blood pressure (NIBP), and electrocardiographic (ECG) activity. During the simulation and initial field application, SpO₂, heart rate, respiratory rate, and temperature were successfully displayed on the bedside monitor and mobile application without significant transmission delay or apparent data transmission errors. These findings demonstrate the practical feasibility of integrating bedside monitoring with telemedicine functions at the primary healthcare level.

The telemedicine function has particular relevance for family-centered neonatal care. The original implementation described the Android application as a means of providing authorized access to infant physiological information, allowing families to receive updates regarding the infant's condition even when they were not continuously present in the clinical environment. Such accessibility can potentially reduce uncertainty and improve communication between healthcare workers and families. Previous research has similarly demonstrated that digital health technologies can support healthcare workers' performance and improve access to health information when they are appropriately integrated into healthcare practice [39]. However, the present implementation should be interpreted as an initial service-strengthening intervention rather than evidence that telemedicine alone improves neonatal clinical outcomes.

The results also demonstrate that successful telemedicine implementation requires more than the availability of digital equipment. During the evaluation process, several non-conformities were identified, including operation that did not fully follow the established SOP, incomplete daily maintenance, and repair procedures that deviated from the prescribed procedures. These findings are important because the reliability of remote monitoring depends on the integrity of the entire measurement chain. Incorrect sensor placement, inadequate maintenance, calibration problems, or inappropriate repair procedures may influence the reliability of physiological data transmitted to the mobile application. Thus, telemedicine system performance must be considered together with equipment management, preventive maintenance, calibration, and user competency.



FIGURE 8. Repair and Calibration of Medical Equipment at the Gedangan Health Center

The technical support activities illustrated in [FIGURE 8](#) further demonstrate the importance of an integrated approach to medical equipment management. During the program, four medical devices at the Gedangan Health Center, including digital sphygmomanometers,

thermometers, and infant scales, were repaired and calibrated. This activity was not directly limited to the Telemedicine-based Bedside Monitor but represented a broader effort to improve the reliability of medical equipment available at the health center. Calibration and repair activities are particularly important in primary healthcare settings because the accuracy of supporting devices can influence clinical decision-making and the continuity of healthcare services.



FIGURE 9. Repair and Calibration of Medical Equipment at the Gedangan Health Center

FIGURE 9 also documents the repair and calibration activities conducted at the Gedangan Health Center. The figure provides visual evidence that the community service intervention incorporated both educational and technical components. The combination of healthcare-worker training and direct technical assistance strengthens the practical relevance of the program because equipment competency cannot be separated from the physical condition of the equipment itself. The activity therefore addressed two interconnected requirements: improving the human capacity to use medical devices and restoring the technical reliability of devices already available at the facility.

The broader implication is that telemedicine-based neonatal monitoring should be implemented as part of an organizational system rather than as an isolated technological intervention. Digital health technologies may improve healthcare-worker performance, but their effectiveness depends on the competencies of users, organizational support, infrastructure, and integration into routine clinical workflows [39]. This is particularly relevant for primary healthcare facilities where healthcare workers may have multiple responsibilities and where dedicated technical personnel may be limited. The findings from the Gedangan Health Center indicate that assigning responsibility for equipment management, providing continuing technical support, and maintaining communication between healthcare and electromedical personnel are important components of sustainable implementation.

C. LIMITATIONS, SUSTAINABILITY, AND FUTURE IMPLEMENTATION

Although the intervention produced improvements in knowledge, practical skills, and SOP compliance, several limitations should be considered when interpreting the findings. First, the training was conducted over only two consecutive days. Such a relatively short intervention

period may be sufficient to introduce the technology and establish basic operational competency, but it may not be sufficient to ensure long-term retention of complex skills such as troubleshooting, calibration, preventive maintenance, and telemedicine system management. The fact that 17% of participants still required partial assistance during re-demonstration supports the need for continued competency development. Previous systematic reviews also indicate that practical and repeated learning opportunities are important for developing sustainable digital competencies among healthcare professionals [35], [36].

Second, the effectiveness of the telemedicine system is dependent on the availability and stability of network connectivity. Although the system successfully transmitted physiological information during simulation and initial implementation, network conditions may vary between operational settings. Interruptions in connectivity could reduce the continuity of remote monitoring and limit the usefulness of the mobile application. Therefore, future implementation should consider network reliability as an essential component of system readiness rather than treating connectivity as a secondary technical issue.

Third, the sustainability of the system requires continuing financial and technical resources. Routine calibration, sensor replacement, equipment repair, software maintenance, and network-related requirements may generate operational costs after the initial community service program has ended. A recent scoping review on health-system strengthening at the primary healthcare level identified organizational processes, contextual conditions, stakeholder engagement, intervention characteristics, and funding as important factors influencing sustainability [40]. This finding supports the recommendation in the present program to establish a preventive maintenance budget and a clear person-in-charge for equipment management.

Fourth, the involvement of families in the telemedicine component remains an area requiring further development. Although the system provides an opportunity for families to access information regarding infant physiological conditions, not all caregivers necessarily possess the same level of digital literacy or confidence in interpreting information displayed through a mobile application. Consequently, future implementation should include a structured educational component for parents or caregivers. Family education should emphasize how to access information, understand basic parameters, recognize abnormal alerts, and communicate appropriately with healthcare workers rather than encouraging families to independently interpret clinical conditions without professional guidance.

The proposed three-month monitoring schedule is therefore important for maintaining the benefits obtained from the intervention. Periodic supervision can identify deviations from SOPs, evaluate equipment conditions, provide refresher training, and reinforce the responsibilities of healthcare workers. A dedicated focal person at the health center can also facilitate communication between clinical staff, electromedical personnel, the academic institution, and the district health

authority. This organizational arrangement can reduce dependence on short-term external interventions and encourage the integration of telemedicine-based monitoring into routine neonatal services.



FIGURE 10. Group Photo with the Head of the Health Center and Participants

Finally, **FIGURE 10** presents the closing group photograph involving the community service team, the Head of the Gedangan Health Center, and the participating healthcare workers. Beyond serving as documentation of the activity, the figure represents the collaborative nature of the intervention between the academic institution and the primary healthcare facility. Such collaboration is important for sustainability because the successful adoption of medical technology requires shared responsibility rather than relying solely on equipment providers or external trainers.

Overall, the findings demonstrate that the Telemedicine-based Bedside Monitor can serve as a feasible technological component for strengthening LBW infant monitoring at the primary healthcare level when accompanied by structured education, practical simulation, technical assistance, and continuous monitoring. Nevertheless, the current findings should be regarded primarily as evidence of improvement in training outcomes, operational competence, and service readiness rather than definitive evidence of improved neonatal morbidity or mortality. Future programs should therefore evaluate longer-term retention of competency, network reliability, frequency of SOP deviations, equipment performance, caregiver engagement, and clinical service outcomes. Expanding the intervention to include family-oriented training and developing interactive, visually oriented SOP modules may further improve technology adoption and support the sustainable integration of telemedicine into routine neonatal healthcare services.

V. CONCLUSIONS

The primary aim of this community service initiative was to implement a Telemedicine-based Bedside Monitor at the Gedangan Community Health Center, Sidoarjo Regency, to strengthen the quality, continuity, and sustainability of neonatal healthcare services for Low Birth Weight (LBW) infants while improving the capacity of healthcare workers in operating, monitoring, maintaining, and troubleshooting the system. The implementation demonstrated that the integration of telemedicine technology with structured counseling, expert demonstration, hands-on practice, re-demonstration,

simulation, and continuous mentoring could improve both theoretical understanding and practical competency in the use of neonatal monitoring equipment. Quantitatively, the mean knowledge score increased from 62.4% in the pre-test to 86.7% in the post-test, representing an improvement of 24.3 percentage points. Practical competency assessment further showed that 83% of participants were able to operate the bedside monitor independently, while 17% still required partial assistance, particularly in sensor placement and mobile application synchronization. Compliance with the established Standard Operating Procedures (SOPs) also increased from an initial level of 54% to 88% following the training intervention, indicating improved procedural consistency in equipment operation. In addition, four medical devices at the health center, including digital sphygmomanometers, thermometers, and infant scales, were successfully repaired and calibrated as part of the technical support activities. The telemedicine system also successfully displayed physiological parameters, including SpO₂, heart rate, respiratory rate, and temperature, on both the bedside monitor and mobile application during simulation and initial implementation without significant transmission delay or apparent transmission errors. These findings indicate that telemedicine-based bedside monitoring can contribute to strengthening healthcare-worker capacity, equipment management, and access to neonatal health information at the primary healthcare level. Nevertheless, the short training duration, dependence on internet connectivity, continuing maintenance requirements, and variation in family digital literacy indicate that sustained implementation requires continuous organizational and technical support. Future work should therefore focus on periodic refresher training and three-monthly monitoring, the appointment of a dedicated focal person for device management, allocation of preventive maintenance resources, improvement of network and system reliability, and expansion of telemedicine education to parents or caregivers. The development of interactive, visually oriented, and video-based SOP modules should also be pursued to facilitate long-term competency retention, improve user adoption, and support the broader integration of telemedicine-based neonatal monitoring into routine primary healthcare services.

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DATA AVAILABILITY

The data supporting the findings of this community service activity are available from the corresponding author upon reasonable request, subject to applicable institutional and privacy requirements.

AUTHOR CONTRIBUTION

B.G.I. conceptualized and supervised the community service program and contributed to the development of the Telemedicine-based Bedside Monitor implementation framework. L. contributed to the development of the training program, coordination with the partner institution, and implementation of the educational activities. A.K. contributed to the technical aspects of medical equipment operation, troubleshooting, repair, and calibration. S.D.M. contributed to data collection, participant evaluation, documentation, and implementation support. M.F.N.P. contributed to the preparation of training materials, practical demonstrations, simulation activities, and data organization. R.R. contributed to field implementation, monitoring, documentation, and manuscript preparation. All authors contributed to the interpretation of the findings, reviewed the manuscript critically, approved the final version, and agreed to be accountable for the work.

DECLARATIONS

ETHICAL APPROVAL

This activity was conducted as a community service and capacity-building program at the Gedangan Community Health Center. Ethical approval requirements should be determined according to the institutional and journal policies applicable to community service activities.

CONSENT FOR PUBLICATION PARTICIPANTS

Participation in the training and evaluation activities was conducted with the involvement of healthcare workers at the partner institution. The authors will confirm and document the applicable participant consent procedure in accordance with institutional requirements before manuscript submission.

COMPETING INTERESTS

The authors declare that they have no competing interests that could have influenced the implementation, evaluation, interpretation, or reporting of this work.

REFERENCES

- [1] S. Vanhaesebrouck et al., "Trends in neonatal morbidity and mortality for very low birthweight infants: A 20-year single-center experience," *J. Matern. Neonatal Med.*, vol. 36, no. 2, p. 2227311, 2023.
- [2] E. L. Haksari et al., "Neonatal mortality and survival of low-birth-weight infants at hospitals in Indonesia, a multicenter study," *Sci. Rep.*, vol. 15, p. 31607, 2025.
- [3] M. Arsyi, "Maternal factors affecting the incidence of low birth weight (LBW) in Indonesia," *Int. J. Pharm. Res.*, vol. 13, no. 1, 2021.
- [4] O. Oktiyanto et al., "Determinants of low birth weight in Indonesia," *J. Kesehat. Masy.*, vol. 17, no. 4, pp. 583–593, 2022.
- [5] V. K. P. Vudathaneni et al., "The impact of telemedicine and remote patient monitoring on healthcare delivery: A comprehensive evaluation," *Cureus*, vol. 16, no. 3, 2024.
- [6] G. F. T. Variane et al., "Remote neonatal neurocritical care: From the bedside to the cloud," *Seminars in Perinatology*, p. 152124, 2025.
- [7] B. G. Irianto, S. Luthfiyah, H. Gumiwang, A. M. Maghfiroh, and A. Kholik, "Enhancing health services through telemedicine: Addressing the gaps in LBW monitoring and training at Puskesmas Gedangan, Sidoarjo Regency," *Front. Community Serv. Empower.*, vol. 3, no. 3, 2024.
- [8] X. Li, L. Huang, H. Zhang, and Z. Liang, "Enabling telemedicine from the system-level perspective: Scoping review," *J. Med. Internet Res.*, vol. 27, p. e65932, 2025.
- [9] J. Barbosa da Silva et al., "A digital transformation for primary health care," *Bull. World Health Organ.*, 2024.
- [10] World Health Organization, *Implementing the Primary Health Care Approach: A Primer*. Geneva, Switzerland: WHO, 2024.
- [11] C. R. Hodgson, R. Mehra, and L. S. Franck, "Child and family outcomes and experiences related to family-centered care interventions for hospitalized pediatric patients: A systematic review," *Children*, vol. 11, no. 8, p. 949, 2024.
- [12] "Infant and family outcomes and experiences related to family-centered care interventions in the NICU: A systematic review," *Children*, vol. 12, no. 3, p. 290, 2025.
- [13] B. G. Irianto, A. M. Maghfiroh, M. Sofie, Y. Kusmiati, and A. Kholik, "Telemedicine-based baby incubator system with DWT method to detect respiratory rate from electrocardiogram signals," *TELKOMNIKA*, vol. 22, no. 6, pp. 1358–1368, 2024.
- [14] B. G. Irianto, S. Luthfiyah, and A. M. Maghfiroh, "Advancing healthcare: Integrating telemedicine with baby incubators at Puskesmas Dampit to ensure seamless health services," *Front. Community Serv. Empower.*, vol. 3, no. 1, 2024.
- [15] World Health Organization Regional Office for South-East Asia, *Leveraging Telehealth for Efficient Delivery of Primary Health Care in the WHO South-East Asia Region*. New Delhi, India: WHO SEARO, 2021.
- [16] V. Mishra and M. G. Sharma, "Digital transformation evaluation of telehealth using convergence, maturity, and adoption," *Health Policy Technol.*, vol. 11, no. 4, p. 100684, 2022.
- [17] M. Pešić and S. Pešić, "The role of management in the perception, implementation and sustainability of telemedicine among healthcare workers," in *Proc. CESGED*, 2024, pp. 96–114.
- [18] J. Natarajan et al., "Effectiveness of an interactive educational video on knowledge, skill and satisfaction of nursing students," *Sultan Qaboos Univ. Med. J.*, vol. 22, no. 4, p. 546, 2022.
- [19] D. C. Rodríguez et al., "Experiential learning and mentorship in global health leadership programs: Capturing lessons from across the globe," *Ann. Glob. Health*, vol. 87, no. 1, p. 61, 2021.
- [20] M. Mouchrek, "Empowering experiential education in design: Integrative model and pilot application in an undergraduate experience design course," 2024.
- [21] E. G. Dietz and J. D. Ernst, "Promoting access and equity through experiential learning: Using competency-based coaching and mentoring experiences as a transformative tool," *Zero to Three*, vol. 43, no. 3, pp. 14–21, 2023.
- [22] S. R. Ahmed, H. S. El Mahdy, and M. A. E. E. Elagamy, "Effectiveness of video-assisted versus traditional demonstration teaching program on nurses' performance regarding neonatal cardiopulmonary resuscitation," *Int. Egypt. J. Nurs. Sci. Res.*, vol. 6, no. 3, pp. 22–49, 2025.
- [23] World Health Organization, *Consolidated Telemedicine Implementation Guide*. Geneva, Switzerland: World Health Organization, 2022.
- [24] M. Peyroteo, I. A. Ferreira, L. B. Elvas, J. C. Ferreira, and L. V. Lapão, "Remote monitoring systems for patients with chronic diseases in primary health care: Systematic review," *JMIR mHealth and uHealth*, vol. 9, no. 12, p. e28285, 2021.
- [25] "Effects of simulation technology-based learning on nursing students' learning outcomes: A systematic review and meta-analysis of experimental studies," *Nurse Education Today*, vol. 107, p. 105127, 2021.

- [26] “Authentic learning in healthcare education: A systematic review,” *Nurse Education Today*, vol. 119, p. 105596, 2022.
- [27] L. Abildgren et al., “The effectiveness of improving healthcare teams’ human factor skills using simulation-based training: A systematic review,” *Advances in Simulation*, vol. 7, no. 12, 2022.
- [28] O. M. E. Ramadan, A. M. Alshammari, A. N. Alruwaili, N. B. Elsharkawy, A. Alhaiti, and N. I. M. Baraka, “Nurse-led telemedicine versus in-person lactation support for breastfeeding initiation in mothers of low-birth-weight infants: a non-inferiority randomized controlled trial,” *BMC Pregnancy and Childbirth*, vol. 25, no. 1, p. 1066, 2025.
- [29] V. Mishra and M. G. Sharma, “Digital transformation evaluation of telehealth using convergence, maturity, and adoption,” *Health Policy and Technology*, vol. 11, no. 4, p. 100684, 2022.
- [30] E. Donovan, C. R. Wilcox, S. Patel, A. D. Hay, P. Little, and M. L. Willcox, “Digital interventions for parents of acutely ill children and their treatment-seeking behaviour: a systematic review,” *British Journal of General Practice*, vol. 70, no. 692, pp. e172–e178, 2020.
- [31] S. Neill, A. Rathbone, J. Downey, M. Lakhanpaul, D. Roland, and M. Carey, “Co-production of a mobile application for parents of acutely ill children under five: ‘iPoorly child symptom checker,’” *Journal of Pediatric Nursing*, vol. 89, pp. 91–99, 2026.
- [32] M. Fisher, A. Vishwas, S. Cross, and C. Attoe, “Simulation training for Police and Ambulance Services: improving care for people with mental health needs,” *BMJ Simul. Technol. Enhanc. Learn.*, vol. 6, no. 2, pp. 121–122, 2020, doi: 10.1136/bmjstel-2018-000423.
- [33] K. L. Bagot, N. Moloczij, K. Barclay-Moss, M. Vu, C. F. Bladin, and D. A. Cadilhac, “Sustainable implementation of innovative, technology-based health care practices: A qualitative case study from stroke telemedicine,” *J. Telemed. Telecare*, vol. 26, no. 1–2, pp. 79–91, 2020.
- [34] M. Melindah, “Spatial Distribution of Low Birth Weight Infants (LBW) on Neonatal Mortality in East Java Province in 2020–2022,” *Media Publ. Promosi Keschat. Indones.*, vol. 7, no. 7, pp. 1863–1870, 2024.
- [35] E. Kulju, E. Jarva, A. Oikarinen, M. Hammarén, O. Kanste, and K. Mikkonen, “Educational interventions and their effects on healthcare professionals’ digital competence development: A systematic review,” *International Journal of Medical Informatics*, vol. 185, p. 105396, 2024, doi: 10.1016/j.ijmedinf.2024.105396.
- [36] J. Longhini, G. Rossetini, and A. Palese, “Digital health competencies among health care professionals: Systematic review,” *Journal of Medical Internet Research*, vol. 24, no. 8, p. e36414, 2022, doi: 10.2196/36414.
- [37] C. Patocka, A. Pandya, E. Brennan, L. Lacroix, I. Anderson, H. Ganshorn, and A. K. Hall, “The impact of just-in-time simulation training for healthcare professionals on learning and performance outcomes: A systematic review,” *Simulation in Healthcare*, vol. 19, no. 1S, pp. S32–S40, 2024, doi: 10.1097/SIH.0000000000000764.
- [38] A. W. Calhoun, D. A. Cook, G. Genova, S. M. Kalantar Motamed, M. Waseem, R. Carey, A. Hanson, J. C. K. Chan, C. Camacho, I. Harwayne-Gidansky, B. Walsh, M. White, G. Geis, A. M. Monachino, T. Maa, G. Posner, D. L. Li, and Y. Lin, “Educational and patient care impacts of in situ simulation in healthcare: A systematic review,” *Simulation in Healthcare*, vol. 19, no. 1S, pp. S23–S31, 2024, doi: 10.1097/SIH.0000000000000773.
- [39] S. Borges do Nascimento et al., “The global effect of digital health technologies on health workers’ competencies and health workplace: An umbrella review of systematic reviews and qualitative evidence,” *The Lancet Digital Health*, vol. 5, no. 8, pp. e534–e544, 2023, doi: 10.1016/S2589-7500(23)00092-4.
- [40] A. Muho, C. Brugger, T. Salzmann, K. Wyss, and P. Steinmann, “Sustainability of health system strengthening interventions implemented at primary healthcare level: A scoping review,” *BMJ Open*, vol. 15, no. 4, p. e095516, 2025, doi: 10.1136/bmjopen-2024-095516.