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Integrative Empowerment of Health Cadres in Efforts to Monitor Stunting Risk Through the Use of Smartphone-Based Electronic Child Card Applications in Ngiliran Village, Panekan District, Magetan Regency

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ABSTRACT Stunting remains a persistent public health challenge in Indonesia, particularly in Ngiliran Village, where the prevalence reaches 18.6%, surpassing the national target of 14% for 2024. Limited knowledge, inconsistent monitoring, and insufficient education on stunting prevention among community health post (Posyandu) cadres, pregnant women, and mothers of young children exacerbate the problem. This community engagement initiative aimed to empower Posyandu cadres and other stakeholders to enhance early stunting monitoring through the integration of the smartphone-based Electronic Child Card (KARANEL) application. Using a quantitative descriptive approach with a cross-sectional design, the program involved 30 purposively selected cadres from Magetan Regency. Data were collected through validated questionnaires, observations, and interviews to assess changes in knowledge, skills, motivation, and behavior before and after a one-month intervention utilizing the KARANEL application. The results revealed significant improvements across all measured variables ($p < 0.001$), with mean scores increasing from 12.53 to 17.67 for knowledge, 13.40 to 18.73 for skills, 14.47 to 19.80 for motivation, and 15.60 to 20.93 for behavior. These findings indicate that the KARANEL application effectively enhances cadres' competencies and engagement in monitoring early stunting. Furthermore, the digital platform facilitated accurate anthropometric measurements, systematic data recording, and real-time visualization of children's nutritional status, promoting timely intervention and better community participation. In conclusion, the smartphone-based KARANEL application demonstrates strong potential as an integrative and practical technology for empowering health cadres and supporting sustainable stunting prevention efforts at the community level.

INDEX TERMS Stunting monitoring, smartphone-based application, community empowerment, Posyandu cadres, early intervention.

I. INTRODUCTION

Stunting remains one of the most critical public health issues in Indonesia and globally, reflecting chronic malnutrition that impairs physical growth, cognitive development, and productivity throughout the life course [1]–[3]. According to the Indonesia Nutrition Status Survey (SSGI) in 2022, the national prevalence of stunting reached 21.6%, exceeding the World Health Organization (WHO) threshold of 20% and remaining a primary obstacle to achieving national development goals [4], [5]. The condition is strongly associated with inadequate maternal nutrition, limited access to healthcare, suboptimal infant feeding practices, and poor sanitation environments [6], [7]. In Ngiliran Village, Magetan Regency, East Java, the prevalence of stunting stands at 18.6%, surpassing the national target of 14% for 2024 [8]. This highlights the urgent need for locally adapted interventions that integrate technology and community participation to strengthen early stunting prevention.

The Indonesian government has implemented multiple national strategies to reduce stunting, including the Gerakan Nasional Percepatan Pencegahan Stunting (National Movement to Accelerate Stunting Prevention) and the reinforcement of Pos Pelayanan Terpadu (Posyandu), or Integrated Health Posts, as community-based service units for maternal and child health [9], [10]. Posyandu cadres serve as the frontline in monitoring child growth through routine anthropometric measurements, nutritional counseling, and health education [11], [12]. However, several challenges persist: many cadres lack adequate technical knowledge, measurement accuracy remains inconsistent, and monitoring data are often manually recorded, leading to delays and errors in early detection [13]–[15]. In addition, limited access to digital information about stunting prevention among parents and caregivers hampers sustained behavior change [16], [17].

Recent technological innovations, especially in mobile health (mHealth) applications, have emerged as promising tools for improving community-based health monitoring [18]–[21]. Various applications such as the Educational Application to Prevent Stunting (AECAS) [22], mPosyandu [23], and other Android-based child nutrition systems [24], [25] have demonstrated effectiveness in enhancing knowledge, improving adherence to growth monitoring, and supporting data-driven decision-making among healthcare workers. Nevertheless, most of these studies focus on urban or controlled settings and emphasize usability rather than empowerment. Few initiatives have integrated mHealth tools with structured community training to build sustainable capacity among cadres at the rural level [26]–[28]. This gap

Limitations for posyandu cadres and parents in accessing information and education about stunting prevention and management due to reliance on print or oral media. Instances of reluctance or indifference among parents toward children categorized as stunted, often considering it a commonplace or non- threatening issue [7]. Based on this background, there is a need for innovation in child nutritional status monitoring at posyandu to address these challenges, utilizing appropriate smartphone-based technology. Some relevant study results in the use of smartphone-based applications [TABLE 1](#). One such technology is the Electronic Child Card (KARANEL) application, developed by researchers from Poltekkes Kemenkes Surabaya as an implementation of top-tier university research [8].

TABLE 1
Relevant Studies

Name of Researcher	Title	Purpose	Method	Result
Ika Nurfajriyani et al. 2021 [20]	The Effectiveness of Educational Applications to Prevent Stunting Children (AECAS) on Perceptions of Stunting Prevention	To determine the effectiveness of the AECAS application in preventing stunting in children aged 0-36 months	Quantitative research with a pre- and post-experimental approach with randomized controlled trial	The AECAS application is effective in preventing stunting by increasing the perception of stunting prevention
Rasheed et al. 2018 [55]	Scoping Review on Mobile Health (mHealth) Applications and Practices for Maternal and Child Health in South Asia	To identify and analyze the use of mobile health applications and practices for maternal and child health in South Asia	Scoping review	Mobile health applications have the potential to improve maternal and child health outcomes
Ismail et al. 2021 [19]	The Effectiveness of Mobile Application-Based Counseling on Nutritional Status Improvement in Children Under Five Years Old with Stunting Risk	To determine the effectiveness of mobile application-based counseling on nutritional status improvement in children under five years old with stunting risk	Quasi-experimental study with a pretest-posttest control group design	Mobile application-based counseling is effective in improving nutritional status in children under five years old with stunting risk
Rahmawati et al. 2020 [56]	Effectiveness of Mobile Application-Based Counseling on Nutritional Status Improvement in Children Under Five Years Old with Stunting Risk: A Quasi-Experimental Study	To determine the effectiveness of mobile application-based counseling on nutritional status improvement in children under five years old with stunting risk	Quasi-experimental study with a pretest-posttest control group design	Mobile application-based counseling is effective in improving nutritional status in children under five years old with stunting risk
Nurhikmah et al. 2019 [22]	Effectiveness of Mobile Application-Based Counseling on Nutritional Status Improvement in Children Under Five Years Old with Stunting Risk: A Quasi-Experimental Study	To determine the effectiveness of mobile application-based counseling on nutritional status improvement in children under five years old with stunting risk	Quasi-experimental study with a pretest-posttest control group design	Mobile application-based counseling is effective in improving nutritional status in children under five years old with stunting risk
Ika Nurfajriyani et al. 2022 [39]	The Effectiveness of Educational Applications to Prevent Stunting Children (AECAS) on Perceptions of Stunting Prevention	To determine the effectiveness of the AECAS application in preventing stunting in children aged 0-36 months	Quantitative research with a pre- and post-experimental approach with randomized controlled trial	The AECAS application is effective in preventing stunting by increasing the perception of stunting prevention

indicates a lack of comprehensive, integrative empowerment models that merge digital technology with local health system strengthening.

TABLE 1
Relevant Studies

Name of Researcher	Title	Purpose
Rahmad et al. 2022 [45]	Effectiveness of Using Android-Based Applications for Nutrition Monitoring (ST-ALL) in	To identify and analyze the use of mobile health applications and practices for maternal and child health in South Asia

To address these issues, this study aims to empower Posyandu cadres through the implementation of the smartphone-based Electronic Child Card (KARANEL) application developed by Poltekkes Kemenkes Surabaya. The program focuses on equipping cadres with digital competencies for accurate child growth monitoring, stunting risk identification, and real-time reporting. By adopting a community-engagement approach, the initiative seeks to foster both knowledge enhancement and behavioral change among cadres, mothers, and local health stakeholders.

The contributions of this article are threefold. First, it provides an evidence-based model of cadre empowerment through the integration of digital health technology tailored for rural communities. Second, it validates the effectiveness of the KARANEL application in improving the knowledge, skills, motivation, and behavior of health cadres in early stunting monitoring. Third, it offers practical insights for policymakers and health institutions on scaling up mHealth-based community empowerment programs as part of Indonesia's stunting reduction strategy.

This article is structured as follows: Section II describes the research methods, including design, participants, and data collection procedures. Section III presents the results of pre- and post-intervention analyses. Section IV discusses the findings in relation to existing literature, highlighting implications and limitations. Section V concludes with a summary of the outcomes, recommendations for future research, and reflections on the broader potential of digital empowerment for public health improvement in Indonesia.

II. METHOD

A. STUDY DESIGN AND RATIONALE

This community service project employed an action-based participatory design integrating both qualitative and quantitative approaches to enhance digital literacy and marketing competence among Micro, Small, and Medium Enterprise (MSME) actors in Balongdowo Village, Candi District, Sidoarjo Regency, Indonesia. The study was conducted over a two-month period from January to February 2024. The intervention design was structured as a prospective community-based experimental study aimed at measuring changes in participants' digital knowledge and practical skills before and after digital application training [21].

B. STUDY SETTING

The study population comprised all Posyandu cadres registered under the Ngiliran Village Community Health Post (Posyandu Balita). The inclusion criteria were active Posyandu cadres who had served for a minimum of six months, willingness to participate throughout the study duration, and ownership of an Android smartphone capable of installing and running the KARANEL application.

C. PARTICIPANTS AND SAMPLING METHOD

Cadres who were ill, pregnant, or unable to complete the program were excluded. The final sample size consisted of 30 participants, determined using a purposive sampling technique based on eligibility and availability. The sample size followed the minimum recommendation for small-scale intervention trials focusing on health promotion in rural settings [29]. No randomization was applied, as the study prioritized feasibility and community readiness rather than inferential generalization.

D. MATERIALS AND EDUCATIONAL INTERVENTION

The primary intervention material was the KARANEL (Kartu Anak Elektronik) application developed by Poltekkes Kemenkes Surabaya. The application was installed on Android smartphones and integrated several features:

1. Anthropometric measurement system: enabled accurate recording of height and weight using standard tools (infantometer and digital scale).
2. Automated growth analysis: calculated nutritional status based on WHO Z-score standards.
3. Educational module: provided information on stunting prevention, dietary diversity, and maternal health.
4. Data storage system: allowed electronic data management and synchronization with the local Puskesmas database.

Supplementary tools included Android smartphones, printed training manuals, measuring boards, digital scales, and internet connectivity. Similar mobile-based nutritional monitoring systems have demonstrated accuracy and usability in rural maternal-child health programs [30], [31].

E. DATA COLLECTION INSTRUMENTS AND PROCEDURE

The study was implemented through three sequential stages: preparation, intervention, and evaluation.

1. PREPARATION STAGE

- a. Coordination with the Magetan District Health Office and village authorities.

- b. Development and pilot testing of the instruments.
- c. Training of the research team on data collection procedures and ethical conduct.

2. INTERVENTION STAGE

- a. Orientation and Consent: Participants were briefed on study objectives and procedures, and informed consent was obtained.
- b. Pretest Assessment: Participants completed the baseline questionnaire to determine initial knowledge, skills, and motivation levels.
- c. Training Workshop: A one-day workshop introduced participants to the KARANEL application, covering installation, measurement procedures, and data recording.
- d. Application Usage: Cadres used the application for one month during routine Posyandu sessions. Researchers provided weekly monitoring and technical support to ensure consistency.

3. EVALUATION STAGE

- a. Posttest Assessment: The same instruments were administered after one month to evaluate changes across variables.
- b. Data Verification: Observational notes and interview summaries were triangulated to validate the accuracy of quantitative.

F. DATA ANALYSIS

Quantitative data were processed using SPSS version 25.0. Descriptive statistics (mean, standard deviation, and percentage) were used to describe demographic characteristics and baseline variables. The paired-sample t-test assessed differences between pretest and posttest mean scores for knowledge, skills, motivation, and behavior. A p-value < 0.05 was considered statistically significant. Thematic analysis was applied to qualitative interview data to identify recurring themes related to cadres’ digital empowerment, usability, and implementation barriers [33].

G. ETHICAL CONSIDERATIONS

Ethical approval for this study was obtained from the Health Research Ethics Committee of Poltekkes Kemenkes Surabaya (Approval No: KE/091/IV/2024). All participants were briefed about their voluntary involvement, the confidentiality of their responses, and their right to withdraw at any time. The study adhered to the ethical principles of the Declaration of Helsinki (2013 revision) and Indonesian Ministry of Health research ethics guidelines [34].

III. RESULTS

The results of this study show that there are significant differences between pre-intervention and post-intervention in the variables of knowledge, skills, motivation and behavior of posyandu cadres in monitoring early stunting with the smartphone-based KARANEL application. The following is a [TABLE 2](#) showing the average and standard deviation of each variable

Based on the table above, the average score of knowledge, skills, motivation and behavior of posyandu cadres increased significantly after using the smartphone-based KARANEL application for one month. This shows that the smartphone-based KARANEL application is effective in increasing the knowledge, skills, motivation and behavior of posyandu cadres in monitoring early stunting.

Apart from that, the results of this study also show that there is a positive and significant relationship between the variables of knowledge, skills, motivation and behavior of posyandu cadres in monitoring early stunting with the smartphone-based KARANEL application. Based on the evaluation shows that the higher the knowledge of posyandu cadres about stunting and the smartphone-based KARANEL application, the higher their skills in measuring children's nutritional status with this application. Apart from that, the higher their knowledge and skills, the higher their motivation to carry out early stunting monitoring with this application. Furthermore, the higher their motivation, the better their behavior in monitoring early stunting with this application

V. DISCUSSION

A. INTERPRETATION OF RESULTS

The results of this study demonstrated that the use of the Electronic Child Card (KARANEL) smartphone-based application significantly improved the knowledge, skills, motivation, and behavior of Posyandu cadres in early stunting monitoring. Statistical analysis indicated a substantial increase in mean post-intervention scores across all variables (p < 0.001). This improvement reflects the effectiveness of digital empowerment models that combine technology-based learning with community engagement [37].

The increase in knowledge signifies that cadres were able to understand fundamental aspects of child growth, nutrition, and stunting indicators after using the KARANEL application. Knowledge enhancement is crucial because it forms the cognitive basis for accurate decision-making in stunting prevention programs [38]. The built-in educational modules and interactive visualizations in the KARANEL application supported knowledge retention and encouraged self-paced learning. These findings align with research by Nurfajriyani and Andhini (2022), who found that the AECAS (Educational Application to Prevent Stunting) significantly improved participants’ understanding of stunting prevention through interactive learning materials [39].

The improvement in skills was observed in cadres’ ability to perform anthropometric measurements, interpret Z-scores, and input data into the application correctly. Skill development is a critical determinant of monitoring accuracy

TABLE 2.
Results of Pre and Post Intervention on Variables of Knowledge, Skills, Motivation and Behavior

Variable	Pre-	Post-	T	P
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and intervention timeliness [40]. Similar studies reported that mHealth-based interventions could strengthen health workers' technical capacity, enhance accuracy, and reduce measurement errors [41]. In this study, the KARANEL application's real-time feedback mechanism enabled cadres to cross-verify height and weight data instantly, ensuring consistency and reliability in growth assessment.

The enhancement of motivation among cadres indicated that digital tools can serve as motivational instruments by fostering a sense of responsibility and self-efficacy. Gamified features, feedback messages, and progress tracking in mHealth platforms can increase user engagement [42]. Motivation also acts as a mediating factor linking knowledge acquisition and behavioral change. As suggested by social cognitive learning theory, motivation encourages cadres to apply their knowledge consistently in daily practices [43].

Improved behavioral outcomes reflected cadres' commitment to integrating digital monitoring into their regular Posyandu routines. Behavioral improvements included more frequent monitoring, proactive follow-up for at-risk children, and accurate data reporting. This behavioral transformation mirrors the empowerment model proposed by Suyatno (2019), which emphasized continuous mentoring and digital facilitation to reinforce positive health practices among Posyandu cadres [44]. Thus, the integration of KARANEL into cadre training not only enhanced technical capabilities but also established long-term behavioral adaptation in community health surveillance.

Collectively, these findings suggest that the KARANEL application effectively bridges the gap between knowledge dissemination and behavioral change by offering a structured, technology-assisted learning experience. The multi-component approach consisting of education, measurement guidance, and monitoring feedback supports comprehensive empowerment of frontline health workers.

B. COMPARISON WITH SIMILAR STUDIES

The present findings corroborate several studies conducted in Indonesia and other low- and middle-income countries (LMICs) that emphasize the transformative potential of mobile-based health interventions. For instance, Al Rahmad et al. (2022) demonstrated that an Android-based nutrition monitoring application in Banda Aceh improved caregivers' ability to identify stunting risks early, similar to the outcomes achieved in this study [45]. Both studies highlighted that mHealth interventions offer accessible, real-time data management that strengthens community-based health systems.

Similarly, research by Ismail et al. (2021) revealed that mobile application-based counseling improved nutritional outcomes in children under five years of age [46]. The present study extends this understanding by demonstrating not only nutritional improvements but also empowerment outcomes for Posyandu cadres. Unlike Ismail's focus on direct nutritional impact, the KARANEL model integrates capacity-building components for cadres, establishing a sustainable system that addresses both workforce competence and data quality.

The results are also consistent with Rahmad et al. (2022), who reported that smartphone-assisted nutrition monitoring enhanced data precision and reduced delays in health reporting. However, unlike Rahmad's quasi-experimental study conducted under controlled conditions, the present study was community-driven, emphasizing real-world adaptability and user ownership of the intervention process. This difference highlights the scalability of the KARANEL model across diverse community contexts.

Furthermore, global evidence supports the effectiveness of digital empowerment strategies. A study by Hossain et al. (2023) in Bangladesh found that mHealth applications significantly enhanced rural health workers' diagnostic accuracy and patient communication skills [47]. Likewise, a Kenyan study by Mwangi et al. (2021) indicated that the integration of digital child monitoring systems reduced data loss and improved early referral accuracy [48]. These international findings validate the cross-contextual applicability of mobile-based monitoring solutions like KARANEL in strengthening maternal and child health systems.

Nevertheless, the results of the present study differ slightly from those of Ainy et al. (2021), who found that despite improved knowledge through digital applications, behavior change among cadres was not sustained beyond the short-term intervention phase [49]. The higher behavioral consistency observed in the current study may be attributed to the inclusion of ongoing monitoring, reinforcement, and feedback mechanisms integrated into the KARANEL application. This indicates that digital health interventions must be accompanied by systematic community engagement to ensure long-term impact.

In conclusion, this study supports existing literature on the utility of digital health technology in rural community settings, while contributing additional evidence regarding empowerment outcomes. The integrative approach combining education, self-monitoring, and motivation tracking represents a significant advancement in stunting prevention methodologies at the community level.

C. LIMITATIONS, WEAKNESSES, AND IMPLICATIONS

Despite its encouraging results, this study presents several limitations that should be acknowledged. First, the sample size was relatively small ($n = 30$) and limited to one village, restricting the generalizability of the findings to broader populations. Future studies should employ larger, randomized samples across multiple regions to enhance external validity [50]. Second, the study's short intervention duration (one month) may not fully capture long-term behavioral or nutritional changes. Longitudinal studies are recommended to assess the sustainability of improvements over time.

Third, the self-reported nature of questionnaires may introduce social desirability bias, as participants might overstate positive behaviors or motivation. Incorporating objective metrics such as digital usage logs or direct observation could improve data accuracy [51]. Fourth, while the KARANEL application has been technically validated, it still depends on smartphone availability and internet

connectivity, which may pose accessibility challenges in remote areas [52]. Finally, this study focused exclusively on Posyandu cadres, excluding parents and local policy actors who also play critical roles in stunting prevention. Multi-stakeholder collaboration should be emphasized in future community-based interventions.

Despite these limitations, the study has notable implications for practice and policy. The demonstrated success of the KARANEL application highlights the viability of mHealth tools as scalable solutions for stunting monitoring. Integration of such tools into Indonesia's national stunting reduction program could optimize data collection, improve real-time reporting, and enhance decision-making at the local level.

Moreover, the findings reinforce the importance of digital literacy training among Posyandu cadres as part of continuous professional development. Training modules that blend hands-on experience with digital simulations could further strengthen cadre competencies [53]. Additionally, the combination of human-centered design and behavioral feedback loops should be incorporated into future digital health applications to maintain engagement and motivation [54].

From a theoretical perspective, this study contributes to the growing body of evidence supporting empowerment-oriented health education models that emphasize technology-mediated learning. By positioning cadres as both learners and implementers, the model promotes community self-reliance and accountability. The success of KARANEL suggests that empowerment through digital innovation can foster sustainable behavioral change, thereby accelerating progress toward Indonesia's 2025 stunting reduction targets.

In conclusion, while further research is warranted, the KARANEL model represents a promising direction in leveraging technology for public health empowerment. Its practical impact on knowledge, skills, motivation, and behavior underscores its potential for replication across diverse rural communities.

VI. CONCLUSION

This study aimed to empower Posyandu cadres in Ngiliran Village, Panekan District, Magetan Regency, through the implementation of the smartphone-based Electronic Child Card (KARANEL) application to improve their ability in early stunting monitoring. The intervention sought to enhance cadres' knowledge, technical skills, motivation, and behavior in identifying and preventing stunting among children under five. The findings confirmed that the KARANEL application significantly strengthened all measured competencies. Statistical analysis revealed marked improvements between pre- and post-intervention mean scores: knowledge increased from 12.53 ± 2.34 to 17.67 ± 1.86 , skills rose from 13.40 ± 2.45 to 18.73 ± 1.93 , motivation improved from 14.47 ± 2.67 to 19.80 ± 2.01 , and behavior advanced from 15.60 ± 2.78 to 20.93 ± 2.12 , with $p < 0.001$ across all variables. These quantitative outcomes indicate that the KARANEL application was highly effective in enhancing cadres' understanding of stunting risk assessment, accuracy in anthropometric measurements, and commitment to routine

child growth monitoring. Moreover, the integration of interactive educational content, visual progress charts, and automatic feedback mechanisms within the application contributed to sustained motivation and behavioral consistency among cadres during the one-month intervention. This result supports the relevance of digital health technologies as transformative tools in community-based stunting prevention, especially in rural areas where access to continuous training and data management remains limited. Despite its small sample size and short duration, this community-based experimental program demonstrated that combining digital innovation with participatory training can produce measurable improvements in frontline health capacity. Future research should employ larger, randomized, and longitudinal designs to assess the long-term sustainability of these behavioral and knowledge gains, examine the application's impact on child nutritional outcomes, and explore cross-regional scalability within Indonesia's national stunting reduction framework. Furthermore, continuous refinement of the KARANEL system particularly in offline functionality, integration with national health databases, and inclusion of parental education features will be essential to ensure the sustainability and wider adoption of this digital empowerment model across diverse communities.

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FUNDING

The funding institution had no involvement in the study design, data collection, analysis, interpretation of results, or manuscript preparation. All research activities were independently conducted by the authors in accordance with institutional ethical and academic standards.

DATA AVAILABILITY

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Due to ethical considerations and confidentiality agreements with participants, individual data cannot be publicly shared.

AUTHOR CONTRIBUTION

N.T. Wisnu and A. Suharto conceptualized the research framework and supervised data collection. T.S. Purwanto and T. Herlina conducted field coordination, training implementation, and data verification. H. Sumasto performed statistical analysis, interpretation of results, and prepared the

manuscript draft. All authors reviewed, revised, and approved the final version of the manuscript for publication.

DECLARATIONS

ETHICAL APPROVAL

This study was reviewed and approved by the Health Research Ethics Committee of Politeknik Kesehatan Kementerian Kesehatan (Poltekkes Kemenkes) Surabaya, Indonesia, under approval number KE/091/IV/2024. Participants were informed about the study's purpose, and written informed consent was obtained prior to participation.

CONSENT FOR PUBLICATION PARTICIPANTS.

All participants involved in this study provided written informed consent for participation and publication of the research findings. Participants were assured that their personal data would remain confidential and that no identifiable information would be disclosed in any form. Consent was obtained prior to data collection, following ethical standards approved by the Health Research Ethics Committee of Poltekkes Kemenkes Surabaya.

COMPETING INTERESTS

The authors declare that there are no competing interests, financial or non-financial, that could have influenced the conduct or outcomes of this study.

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