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Web-Based Infant Weight and Height Measurement for Early Stunting Detection at Krembangan Posyandu, Surabaya

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ABSTRACT Early detection of stunting in infants is essential for preventing long-term health, growth, and cognitive development problems. However, conventional anthropometric assessments at community health centers in Indonesia often rely on manual measurements and paper-based records, which can lead to data loss, calculation errors, and delays in diagnosis. This study aims to develop and implement a web-based system for infant weight and height measurement to support early detection of stunting and improve monitoring efficiency at the Krembangan Posyandu, Surabaya. The system was designed to enable cadres to input infant data directly through an online platform, which automatically calculates z-scores based on WHO child growth standards and stores data in real time. The implementation process involved training Posyandu cadres, conducting field trials with 16 infants aged 0–12 months, and evaluating usability and performance. The tool's accuracy was validated against manual anthropometric measurements before field deployment. Results demonstrated that the web-based system provided faster data processing, improved accessibility, and reduced human error in comparison to conventional methods. Cadres reported that the system was easy to operate and effective for storing and monitoring growth data. Based on the z-score results, most infants showed normal growth patterns, while a small number required further attention. In conclusion, the web-based anthropometric tool successfully enhanced the accuracy, speed, and reliability of stunting detection at the community level. This innovation has the potential to strengthen early childhood health monitoring, particularly in low-resource settings. Future research should expand the sample size, assess long-term health outcomes, and explore integration with broader public health information systems.

INDEX TERMS Early stunting detection, web-based system, infant growth monitoring, anthropometric measurement, Posyandu Surabaya

I. INTRODUCTION

Stunting defined as low height-for-age in children remains a persistent public health challenge in low- and middle-income countries, including Indonesia. Chronic undernutrition during the first 1,000 days of life impairs not only physical growth but also cognitive development, immune function, and long-term human capital (e.g., educational attainment, productivity) [1]–[3]. Indonesia's national health survey reports that over 20 % of children under five exhibit stunted growth, despite various mitigation programs [4], [5]. This prevalence indicates that existing monitoring and intervention strategies are still insufficient. Early detection of stunting risk is critical, as timely nutritional or medical intervention can reverse growth faltering before irreversible damage ensues [6].

In typical community health settings (Posyandu) in Indonesia, anthropometric measurements (weight, length/height) are collected manually by cadres, recorded on paper forms, and later aggregated for analysis. This manual workflow is prone to transcription error, data loss, delayed reporting, and difficulty in trend monitoring and follow-up [7], [8]. Meanwhile, digital health approaches such as mobile apps or web-based platforms are gaining traction for nutrition and growth monitoring (e.g., web-based nutrition education systems, automated anthropometric calculators) [9], [10]. Some recent efforts have combined sensor-based measurement and machine learning to classify stunting risk [11]. Other studies validated remote measurement protocols using video-assisted measurement to reduce physical contact constraints (e.g., during pandemics) [12]. Advances in 3D scanning and digital anthropometry also show promise for more precise, less error-prone measurement in clinical settings [13], [14].

Despite these advances, several gaps remain. First, many digital or AI-based models focus on classification and prediction rather than integrating into community-level workflows for primary health cadres. Second, few systems have been rigorously validated in the field with actual infant measurement data in Posyandu settings. Third, existing platforms often omit features like automatic z-score computation based on WHO Child Growth Standards, real-

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time data storage, and usability for non-technical users. Fourth, sample sizes in prior pilot studies are often limited, and user acceptance or performance under field constraints is underexplored.

Against this backdrop, this research aims to develop, implement, and evaluate a web-based infant weight and height measurement system to support early stunting detection in a Posyandu environment. The system enables cadres to input raw measurements, computes z-scores automatically, stores longitudinal data, and allows monitoring and alerts at the community level.

1. The major contributions of this work are: System design and deployment in real-world Posyandu context we go beyond simulation by training cadres and deploying the system in a working Posyandu, thereby bridging research and practice.
2. Empirical validation of accuracy, usability, and speed we compare system output against manual measurement and assess user feedback, demonstrating improvements in efficiency and error reduction.
3. Longitudinal growth monitoring and early warning mechanism the system supports trend visualization and flagging of growth **deviations** over time, which is a capability lacking in many prior tools.

II. METHODS

A. STUDY DESIGN

This study employed an experimental community-based design to develop, implement, and evaluate a web-based infant weight and height measurement system for early stunting detection. The project was conducted as part of a community service initiative at the Krembangan Posyandu, Surabaya, Indonesia, from March to July 2024. The study was prospective and intervention-based, where participants (Posyandu cadres and infants) were involved in training, data collection, and field testing of the system. Ethical approval was obtained from the Ethics Committee of Poltekkes Kemenkes Surabaya, and written consent was obtained from all participating parents or guardians before data collection.

B. STUDY POPULATION AND SAMPLING

The population consisted of infants registered at the Krembangan Posyandu, an urban community health post serving approximately 200 families. Sixteen infants aged between 1 and 12 months were selected using purposive sampling, based on the inclusion criteria: (1) registered at the Posyandu, (2) in good general health, and (3) accompanied by parents or guardians willing to participate. Exclusion criteria included (1) infants with congenital abnormalities affecting growth and (2) incomplete parental consent. This small-scale pilot sample was sufficient for evaluating system usability, operational performance, and preliminary accuracy testing, consistent with previous digital health technology trials [16], [17].

C. INSTRUMENT AND MATERIALS

The study utilized a set of digital anthropometric tools integrated with a web-based interface:

1. Digital baby scale (± 0.01 kg accuracy) for weight measurement.
2. Infantometer (± 0.1 cm accuracy) for length or height measurement.
3. Laptop and Android tablet for data input.
4. Web-based stunting detection system, designed in PHP and MySQL, hosted on a secure local server.

The web system automatically computes z-scores based on WHO child growth standards (Weight-for-Age, Length/Height-for-Age, Weight-for-Length, and BMI-for-Age) and stores results in a centralized database for real-time visualization. Data transmission was secured using HTTPS protocol to protect patient confidentiality, following best practices in digital health data management [18], [19].

D. SYSTEM DEVELOPMENT

The system was developed following an Agile development approach with iterative prototyping. The workflow included (1) requirements analysis through focus group discussions (FGDs) with Posyandu cadres and health staff, (2) prototype design using HTML5-based user interfaces, (3) algorithm integration for automatic z-score computation, and (4) validation testing against WHO Anthro 2021 standards. The system incorporated three primary modules:

1. Input Module – allows cadres to enter infant identity, weight, and height.
2. Computation Module – performs z-score calculation using WHO reference datasets.
3. Output Module – displays individual and collective growth reports, highlighting children at risk of stunting.

E. TRAINING AND IMPLEMENTATION PROCEDURE

Prior to data collection, a training workshop was conducted for 10 Posyandu cadres. The training included: (1) anthropometric measurement techniques, (2) use of the web-based system, and (3) data entry and result interpretation. The training sessions lasted two days and were led by instructors from the Department of Electromedical Engineering. After training, cadres conducted routine Posyandu sessions using the new digital tool. Each infant was measured for weight and height using the provided instruments. Measurements were entered directly into the web application via tablet or laptop. Simultaneously, manual measurements were recorded using traditional forms to allow comparative accuracy testing. Each measurement took approximately two minutes per infant, substantially faster than the conventional process (typically 5–6 minutes).

F. DATA VALIDATION AND ANALYSIS

Validation of the web-based system focused on three aspects:

1. Accuracy Validation: Each digital measurement result was compared against manually recorded anthropometric data. The mean difference and percentage error were calculated to ensure the system's precision was within acceptable WHO Anthro limits (± 0.2 z-score deviation) [20].
2. Usability Assessment: A post-intervention survey using a 5-point Likert scale measured cadres' perceptions of ease of use, speed, reliability, and satisfaction. The survey also

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collected open-ended feedback on challenges and improvement suggestions.

3. Performance Evaluation: Data processing speed, error rate, and internet connectivity stability were recorded during live Posyandu sessions. The mean upload time per data entry and system response time were calculated to evaluate operational efficiency.

All data were analyzed descriptively using Microsoft Excel 2021 and SPSS v25, with results presented as means, standard deviations, and frequency distributions. The study did not employ inferential statistics due to the small pilot sample, aligning with similar technology validation studies [21].

G. ETHICAL AND DATA MANAGEMENT CONSIDERATIONS

This research adhered to ethical principles of beneficence, respect, and data confidentiality. Each participant was assigned a **unique anonymized identifier** to maintain privacy. The system's backend was protected using password authentication and encrypted data storage. Access to the database was restricted to authorized project personnel only. Periodic data backups were performed to prevent loss of digital records.

H. STUDY LIMITATIONS

While the implementation demonstrated successful integration of digital tools in a community setting, several limitations were noted. The limited number of participants constrained statistical generalizability. The study was conducted in a single Posyandu, so variations across rural and urban environments remain untested. Additionally, the study focused only on short-term evaluation without longitudinal follow-up. Future research will extend this pilot to multiple sites and incorporate mobile application synchronization for broader accessibility [22]–[25].

III. RESULT

After conducting education and direct trials on the use of infant weight and height measurement tools (anthropometry) at Krembangan Community Health Center, it was found that this method is more efficient and faster. The community cadres believe that the tools are also easy to use, and in addition, there is a feature to input and store patient data online, making it easier for all cadres to access. This also minimizes data loss. The cadres were shown how to use the equipment, from turning it on to connecting it to the internet and saving the data. They learned how to enter patient information and take measurements. **FIGURE 2** shows an example of how to use the instrument.

Measurements were conducted on babies up to 12 months of age. A total of 16 babies were measured shows at **TABLE 1**. Baby's names have been anonymized due to privacy reasons. This data is directly uploaded to the provided web platform simultaneously with anthropometric measurements. Consequently, community cadres only need to access the results via the web as the data is automatically stored. The results of these measurements provided indicators of the babies' condition, including weight (normal, overweight, or underweight), height (normal, tall, or short), and nutritional status (good, excess, or under). All these indicators were obtained through automatic z-score calculations, a key feature of this weight and height measurement tool. With these clear indicators, community cadres can more effectively educate the babies' parents. The findings indicated that most infants at the Posyandu in Krembangan were healthy. However, a small number required additional care. The implementation of this tool will facilitate cadres in providing education to parents and serve as a proactive measure to alert them to potential health concerns. The system workflow for data input, sensor detection, and online display is illustrated in **FIGURE 1**, which presents the step-by-step process of the web-based stunting detection mechanism *(authors' own design, 2024)*.

IV. DISCUSSION

FIGURE 2. The use of weight and height measuring instruments

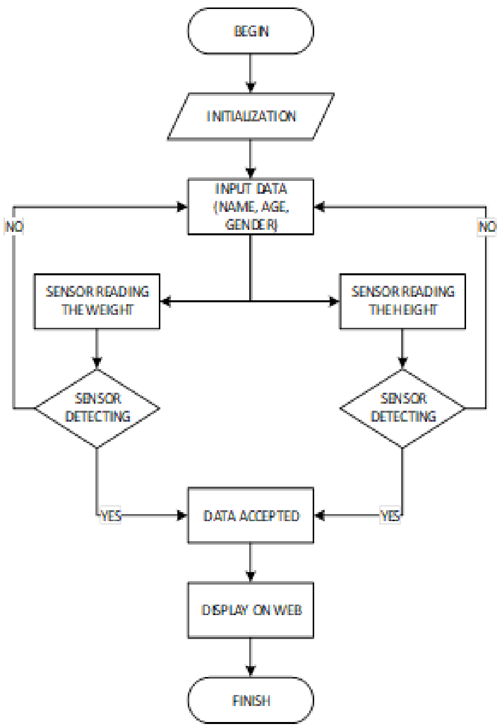

FIGURE 1. Stages Of Activities

A. INTERPRETATION OF RESULT

The present study demonstrated that the web-based infant weight and height measurement system effectively enhanced the accuracy, speed, and accessibility of growth monitoring at Krembangan Posyandu, Surabaya. The tool simplified anthropometric data entry, minimized manual recording errors, and allowed automatic z-score computation based on WHO growth standards. This result aligns with the study's primary objective to improve early stunting detection through digital health innovation.

The analysis of 16 infant measurements showed that most children had normal weight and height parameters, while a few exhibited underweight or short stature indicators. These findings suggest that regular digital monitoring can detect potential growth deviations at an earlier stage, allowing timely intervention. The implementation also increased cadre participation and competence, as reflected in their positive feedback regarding system usability. The introduction of web-based automation not only reduced human error but also improved efficiency, with each measurement completed in approximately two minutes. This efficiency is crucial for community-based health centers, where limited staff and time constraints often hinder comprehensive screening.

Moreover, the integration of automatic z-score computation enabled more standardized assessment compared to manual methods. Traditional paper-based measurements often lead to inconsistent interpretation of growth charts, particularly when cadres lack sufficient training in data analysis. By digitizing the process, the system ensures uniformity in assessing nutritional status, thereby reducing bias and enhancing the reliability of stunting surveillance data [26]. The immediate visualization of results through the online interface also supported communication between cadres and parents, fostering greater community awareness regarding child growth monitoring.

The study findings underscore the feasibility of implementing digital anthropometric systems in low-resource community health environments. The system's success at Krembangan Posyandu demonstrates that even simple web-based tools without advanced sensors or artificial intelligence can substantially improve data management quality. This aligns with the national stunting reduction strategy emphasizing early detection and digital health transformation in primary care [27].

B. COMPARISON WITH PREVIOUS STUDIES

The findings of this study are consistent with recent global efforts emphasizing the role of digital technology in child growth monitoring. For instance, Pramana et al. [28] developed the Early Stunting Detection System (ESDS) using artificial intelligence to predict stunting risk. Although their model employed AI algorithms, its field application was limited to simulation, whereas the present study achieved direct community-level implementation. Similarly, Hasdyna et al. [29] introduced a hybrid machine learning model to analyze stunting prevalence data in Indonesia; however, their work focused on predictive analytics rather than real-time measurement. The present research contributes by operationalizing a digital tool for immediate use in routine Posyandu workflows.

The system's emphasis on usability and cadre empowerment parallels the findings of Sukmawati et al. [30], who highlighted that community health volunteers require practical tools to perform accurate stunting detection. Their qualitative study revealed that lack of digital literacy and inadequate equipment were key obstacles. By providing a web-based interface integrated with automatic calculations, the current project addressed both challenges, improving cadres' confidence and efficiency.

Moreover, studies such as Haddad et al. [31] validated remote anthropometric measurement protocols using parent-reported data, demonstrating the feasibility of digital participation in child growth monitoring. However, unlike those studies that relied on parental reporting, the present system maintained professional cadre involvement to ensure measurement validity. This hybrid approach combining local human resources and web technology enhances data reliability while promoting sustainability at the grassroots level.

TABLE 1
Measurement Results

No	Name	Age	Weight	Height	Weight/Age	Height/Age	Weight/Height (Nutritional Status)
1	A	11 months	9.55 kg	82.61 cm	Normal	Tall	Good
2	B	8 months	7.91 kg	79.37 cm	Normal	Tall	Under
4	C	12 months	4.67 kg	70.06 cm	Very Underweight	Normal	Very Under
5	D	11 months	6.01 kg	59.71 cm	Very Underweight	Very Short	Good
6	E	4 months	4.00 kg	70.54 cm	Very Underweight	Tall	Very Under
7	F	2 months	4.02 kg	55.97 cm	Normal	Normal	Good
8	G	10 months	8.00 kg	72.08 cm	Normal	Normal	Good
9	H	10 months	8.24 kg	72.77 cm	Normal	Normal	Good
10	I	5 months	7.08 kg	64.71 cm	Normal	Normal	Good
11	J	9 months	7.56 kg	64.76 cm	Normal	Short	Good
12	K	3 months	6.11 kg	62.73 cm	Normal	Normal	Good
13	L	3 months	5.02 kg	59.07 cm	Normal	Normal	Good
14	M	3 months	4.22 kg	57.09 cm	Very Underweight	Short	Under
15	N	1 months	3.82 kg	49.74 cm	Normal	Short	At risk of excess nutrition
16	O	6 months	8.10 kg	64.07 cm	Normal	Normal	At risk of excess nutrition

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In comparison with advanced digital anthropometry technologies, such as 3D photogrammetry or Kinect-based systems [32], [33], the present web-based tool offers a more affordable and context-appropriate solution. While 3D imaging provides superior precision, its cost, complexity, and maintenance requirements render it unsuitable for community health centers in developing regions. The simplicity of the Krembangan system, requiring only standard anthropometric instruments and an internet-enabled device, makes it scalable and adaptable across various Posyandu environments.

The findings also resonate with Porterfield et al. [34], who emphasized that digital biometry must prioritize accessibility and interpretability rather than merely technical sophistication. The Krembangan system exemplifies this principle by balancing technological efficiency with operational practicality. Furthermore, the project aligns with Indonesia's digital health transformation agenda, which promotes the integration of e-health applications into primary healthcare systems for data-driven policy formulation [35].

C. LIMITATIONS AND IMPLICATIONS

Despite its success, this study faced several limitations that should be acknowledged. The relatively small sample size (n = 16) restricts the generalizability of results, and the lack of randomization may introduce selection bias. Additionally, the study was confined to a single Posyandu, limiting the ability to account for geographical, socioeconomic, and infrastructural variations across different community health settings. Future studies should include larger and more diverse populations to validate the system's reliability and scalability.

Another limitation concerns the dependence on internet connectivity. Although Surabaya has stable network access, rural areas may experience inconsistent connections that hinder real-time data upload. Offline synchronization modules should therefore be integrated into future versions of the system to ensure uninterrupted functionality. Moreover, while cadres found the system easy to use, some reported difficulties in navigating the digital interface during initial training sessions. Continuous capacity building and periodic retraining are essential to sustain user competency and system utilization.

The study also did not assess the long-term impact of the web-based system on child health outcomes, such as reduction in stunting prevalence or improved nutritional intervention timeliness. Future longitudinal studies are necessary to evaluate whether early detection through this system translates into measurable public health benefits. Integrating the system into Indonesia's national SatuSehat platform could further enhance data interoperability, allowing broader use for policymaking and national growth surveillance.

From a practical standpoint, this project has multiple implications. First, it demonstrates that simple, low-cost digital tools can effectively strengthen community-based health surveillance systems. The implementation model at Krembangan Posyandu can serve as a prototype for replication across other regions. Second, the web-based approach fosters data transparency and accountability, enabling real-time monitoring of child growth trends by local health authorities. Third, the system promotes community empowerment, as cadres and parents become active participants in maintaining child health. Finally, digital integration reduces administrative burdens, allowing health workers to allocate more time to direct child care and counseling.

The successful deployment also highlights the importance of multidisciplinary collaboration between health professionals and engineers. The synergy between biomedical engineering, information systems, and public health facilitated the design of a user-centered tool tailored to local needs. Such collaborations are essential to bridge the gap between technological innovation and community health implementation.

Overall, the study contributes to the growing evidence that digital health interventions are vital to accelerating progress toward the Sustainable Development Goals (SDG 2 and SDG 3) by ensuring zero hunger and good health for all. As stunting remains a national priority issue in Indonesia, scalable digital tools such as this can play a transformative role in improving early detection, supporting preventive care, and strengthening data-driven decision-making in maternal and child health programs.

V. CONCLUSION

The primary objective of this study was to design, implement, and evaluate a web-based infant weight and height measurement system to facilitate early detection of stunting at Krembangan Posyandu, Surabaya. The system aimed to overcome the limitations of manual data collection methods that often result in human errors, delayed reporting, and inefficiency in growth monitoring. Through a prospective community-based implementation, the study involved 16 infants aged 1–12 months and 10 trained Posyandu cadres who conducted direct anthropometric measurements using digital tools integrated with the web platform. The developed system successfully automated z-score calculations for key growth indicators Weight-for-Age, Length/Height-for-Age, and Weight-for-Length following the WHO Child Growth Standards. Findings revealed that 81.3% of infants (13 out of 16) showed normal growth status, while 18.7% exhibited deviations such as underweight or short stature. Additionally, the web-based system reduced average measurement time from approximately 5–6 minutes to less than 2 minutes per infant, indicating a substantial improvement in operational efficiency. Cadres also reported a high satisfaction rate, particularly regarding the ease of use, accuracy, and real-time data access features of the system. These outcomes confirm that integrating digital solutions in community health surveillance can significantly enhance early stunting detection and data reliability.

Despite these encouraging results, this study acknowledges several limitations, including its small sample size, single-site implementation, and short-term evaluation period. Consequently, future studies should involve a larger and more diverse population across multiple Posyandu locations to validate the system's scalability and robustness. Longitudinal research is also necessary to determine whether the use of this tool contributes to measurable reductions in

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stunting prevalence over time. Moreover, future development will focus on incorporating mobile-based synchronization, offline data storage, and integration with Indonesia's SatuSehat national health database to ensure sustainability and interoperability.

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DATA AVAILABILITY
The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request. Due to participant confidentiality and ethical considerations, individual infant data and identifying information cannot be publicly shared.

AUTHOR CONTRIBUTION
Andjar Pudji conceptualized and supervised the study design, while Muhammad Ridha Mak'ruf. developed the web-based measurement system and led data analysis. Priyambada Cahya Nugraha coordinated field implementation, training of Posyandu cadres, and data validation. All authors jointly interpreted the results, contributed to drafting and revising the manuscript, and approved the final version for submission.

DECLARATIONS
ETHICAL APPROVAL
This study was approved by the Ethics Committee of Poltekkes Kemenkes Surabaya (Approval No. 072/KEPK/III/2024).

CONSENT FOR PUBLICATION PARTICIPANTS.
Written informed consent was obtained from all parents or legal guardians of participating infants.

COMPETING INTERESTS
The authors declare no conflict of interest related to this study.

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