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Developing a Nutritional Assessment Tool for Toddlers Using Anthropometry and IoT Technology

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ABSTRACT Data from the Indonesian Toddler Nutrition Status Survey (SSGBI) in 2021, the prevalence of stunting in Indonesia is still quite high, at 24.4%, which is equivalent to 5.33 million toddlers. This figure is still above the standard tolerated by WHO, which is below 20%. Therefore, efforts are needed to accelerate stunting reduction so that the prevalence of stunting in toddlers decreases to 19.4% by 2024. This research aims to develop a tool for measuring toddlers' height and weight to assess their nutritional status promptly, aiming to preemptively address any nutritional abnormalities and prevent exacerbation. Anthropometry serves as the primary method for assessing toddlers' nutritional status in this study. The tool's design incorporates the ESP32 as the main control unit, the HC-SR04 sensor for height measurements, and the HX711 module and loadcell sensor as weight sensors. Data from the sensor are transmitted from the ESP32 master to the ESP32 slave for processing, culminating in a nutritional status assessment. Notably, the tool boasts a minimal error rate of 0.18% for weight measurement with 99.82% accuracy and a 2.66% error rate for height measurement with 97.34% accuracy. Furthermore, the tool's integration with IoT technology offers additional advantages. It facilitates real-time data transmission and analysis, enabling healthcare professionals to promptly identify any nutritional issues in toddlers. This, in turn, allows for timely intervention and appropriate management strategies to prevent the development or exacerbation of stunting. Overall, the benefits of this research for the Anthropometry Stunting Monitor based on IoT are manifold. It enhances accuracy and efficiency in measuring toddlers' height and weight, enables early detection of stunting, and facilitates timely intervention to address nutritional abnormalities. This holds significant promise for improving pediatric healthcare outcomes and reducing the prevalence of stunting among children.

INDEX TERMS Anthropometry, Stunting, Nutritional Status, IoT

I. INTRODUCTION

Nutritional status has a major influence on a child's growth and development [1]. Good quality nutrition, starting from the time the mother is pregnant until after the baby is born, plays a vital role in preventing growth problems such as stunting, a serious challenge facing many countries, including Indonesia [2]. Stunting, which is a condition in which a child has a shorter height than it should be for his age, is in the global spotlight [3].

The prevalence of stunting in the world as a whole has decreased significantly from 32.7% to 22.9% in the period 2000 to 2016. Likewise, the prevalence of stunting in Southeast Asia has decreased from 51.3% to 35.8% in the same period [4]. However, the situation in Indonesia still shows significant challenges. Based on data from the Indonesian Toddler Nutrition Status Survey (SSGBI) in 2021, the prevalence of stunting in Indonesia is still quite high, at 24.4%, which is equivalent to 5.33 million toddlers. This figure is still above the standard tolerated by WHO, which is below 20% [5]. In addition, stunting, as one of the targets identified in the Sustainable Development Goals (SDGs), plays an important role in efforts to eliminate hunger and all forms of malnutrition by 2030 and achieve sustainable food security [6]. Therefore, efforts are needed to accelerate stunting reduction so that the prevalence of stunting in toddlers decreases to 19.4% by 2024 [7].To find out whether children have a risk of stunting or not, anthropometric measurements can be done periodically and to determine the nutritional status of children can be done using z-score calculations [8].

Anthropometry is the most commonly used approach to assess nutritional needs in children [9]. In this regard, although there are various other sources, such as biochemical, clinical, and dietary data analysis, anthropometry is the most widely used source for nutritional assessment, due to its non-invasive, inexpensive, and, more importantly, satisfactory results [10]. In addition, anthropometric measurements are very sensitive to a broad spectrum of nutritional status, while biochemical and clinical indicators are useful only at the extremes of malnutrition. Among the widely used anthropometric measurements, body mass index (BMI) and upper arm circumference (MUAC) are the most significant and reliable [11]. The core elements of anthropometry include height, weight, head circumference, body mass index (BMI), body circumference to assess adiposity (waist, hips, and limbs), and skin fold thickness [12].

Stunting is a condition of failure to thrive in children under five due to chronic malnutrition so that children are shorter for their age [13]. According to the World Health Organization (WHO) Child Growth Standard, stunting is based on an index of body length to age (BL/A) or height to age (BH/A) with a z-score of less than -2 SD [14]. The stunting grouping is obtained by matching the z-score calculation results in the Z-Score table [15]. Nutritional problems such as stunting can also be harmful to infants because they can lead to emotional, social, and cognitive development problems in adulthood. In addition, childhood stunting increases the risk of mortality, deficits in cognitive function, poor motor development, and loss of physical growth potential [16]. Studies have found that stunted children might not grow as tall as they could have and struggle with thinking and learning, which can affect how well they do in school and their future opportunities for success in life [17][18][19]. Stunted children do not achieve their full developmental potential leading to poorer cognitive performance and educational achievement compared to their well-nourished counterparts. Memory and locomotor skills can be altered as well.

Preventing and treating stunting and its causes requires finding actions that can help a child grow taller and healthier. This involves different sectors working together to coordinate efforts [20]. To monitor stunting in children, it is necessary to take anthropometric measurements periodically, usually every month until the age of two [21]. These measurements can be taken by trained health workers and use appropriate tools, such as height tapes and weight scales [22]. The results of the child's anthropometric measurements are then compared with child growth standards provided by the World Health Organization (WHO), to determine whether the child is at risk of stunting or not. If a child is found to be at risk of stunting, then appropriate nutritional and health intervention measures can be taken to prevent the condition from worsening. However, stunting handling is still faced with several obstacles, especially the limited number of health workers and the manual recording system. The number of midwives in Indonesia is not proportional to the number of toddlers who have to be handled, creating a heavy workload for health workers. In addition, the complicated process of determining children's nutritional status with calculations based on the WHO formula adds complexity to handling stunting cases [23]. As a result, nutritional interventions are often not suited to the child's needs.

Based on this, innovative solutions are needed to improve stunting detection and treatment systems. One of the proposed solutions is the development of Anthropometry and Stunting Monitoring tools Based on Wireless Devices (Internet of Things / IoT). By utilizing Internet of Things / IoT technology, this tool is expected to facilitate measurement and monitoring of toddler nutritional status more quickly, accurately, and efficiently. The use of this technology is expected to accelerate the stunting detection system towards the Industrial Revolution 4.0 era, make it easier for users to monitor measurement results and nutritional status of toddlers, and improve the effectiveness of recording and analyzing overall data.

II. METHODS

This research uses methods called qualitative and experimental. The focus is on measuring the height and weight of young children and evaluating their nutrition. The tools and programs created should work well. To ensure this, researchers conduct periodic trials. By trying different ways to make this tool easy to use and give accurate results. In FIGURE 1, there are three main parts, namely input, process, and output. Input in the form of sensors that measure the child's height and weight, as well as data about the child's age and gender.

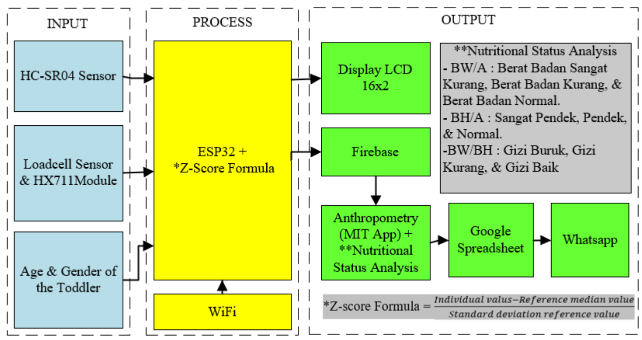

FIGURE 1. **Block Diagram from Anthropometry And Stunting Monitor**

All this data is processed by a small computer connected to the internet. This microcontroller will calculate the nutritional status of the child based on the data received. The results are then sent to an app on the user's smartphone and also stored in Google Sheets that can be accessed by health workers.

During this process, as in FIGURE 2 the data is processed and displayed interactively on the user's smartphone screen. Users can view information about the child's height and weight, as well as his nutritional status. In addition, there is also a feature that allows health workers to send messages to children's parents via WhatsApp with this information.

From FIGURE 3, it can be seen that there are four different displays: splash screen, identity input, measurement results display, and nutritional conditions. Each display is equipped with a textbox, checkbox, and button columns that have been tailored to the needs of each section.

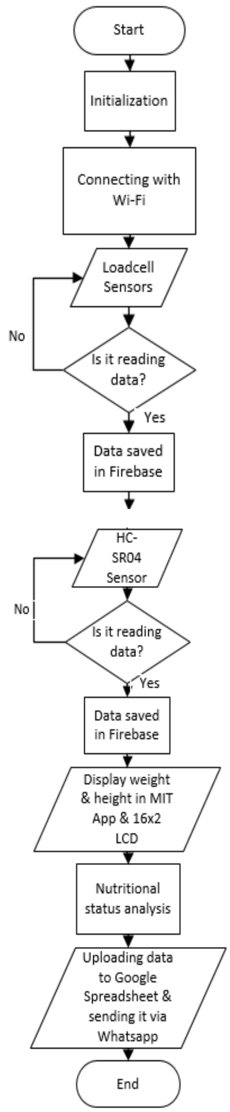

FIGURE 2. Application Flowchart

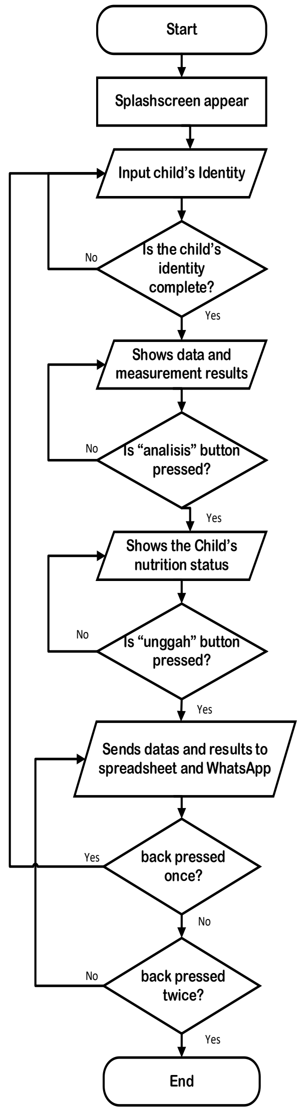

FIGURE 3. Program Flowchart

The usage of the ESP32 microcontroller as shown in FIGURE 4 involves processing incoming data, both from sensors and manually inputted data through the application. The identity input section must be filled out to proceed to the next page. The results display section also shows the personal data previously entered before being uploaded along with the measurement results and nutritional status to Google Spreadsheet and WhatsApp.

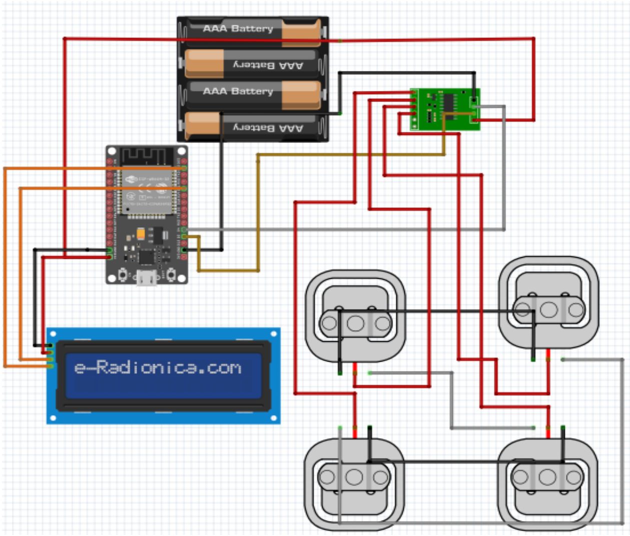

FIGURE 4. **System Circuit of the Scale**

The incoming data consists of the child's weight data obtained from the output of the HX711 module, the child's height data obtained from the output of the HCSR-04 sensor as shown in FIGURE 5 and manually entered data of the child's age and gender.

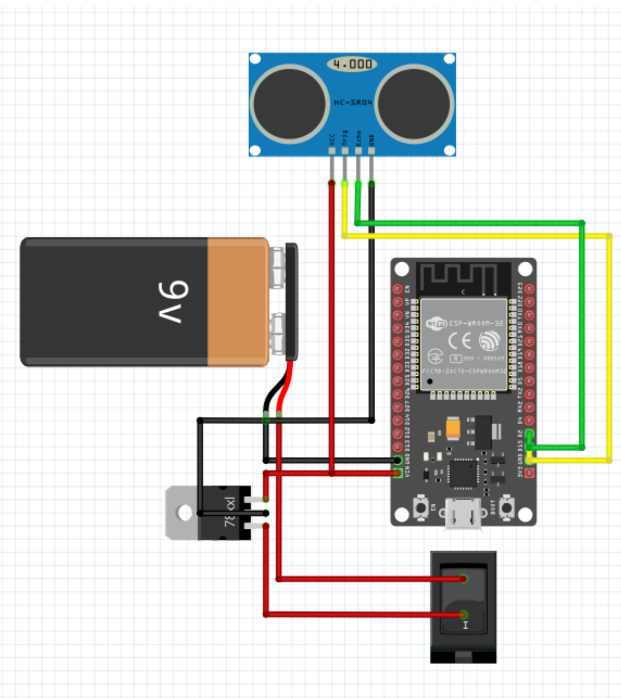

FIGURE 5. **Circuit System of Height Measurement**

From these data, the child's weight and length will be directly displayed on the 16x2 LCD. Additionally, the program will calculate the child's z-score value, which has been adjusted according to the established rules. The WhatsApp number input is also incorporated into the application.

III. RESULT

The accuracy of the Anthropometry and IoT-based Stunting Monitor tool was verified through calibration against weight and height measuring instruments (meters). As indicated in TABLE 1, for weight measurements ranging from 1 kg to 20 kg, the average measurement obtained using the anthropometry tool (wtd) was 9.982 kg compared to the standard weight (wts) of 10 kg. This resulted in an average error of 0.017619048 kg (lp=-wtd) and an accuracy value of 99.82%.

TABEL 1
Calculation of Error Values and Accuracy of the Weight Measurement Equipment Made (wtd)

	Weight
% error	(wts-wtd)/wts x100%
% error	(10-9.982)/10 x100%
% error	0.18%
% accuracy	100%-%kesalahan
	99.82%

Similarly, for height measurements using the anthropometry tool (hts) according to TABLE 2, the average measurement was 49.734 cm compared to 50 cm using the meter. This yielded an error value of 1.639047619 cm (lp=-wtd) and an accuracy of 97.34%. These results demonstrate that the weight and height measurements obtained using the anthropometry and IoT-based stunting monitor tool exhibit high accuracy, exceeding 97.34%.FC

TABEL 2
Calculation of Error Values And Accuracy of the High Tools Created (htd)

	Height
% error	(hts-htd)/hts x100%
% error	(50-49.734)/hts x100%
% error	2.66%
%accuracy	100%-%kesalahan
	97.34%

IV. DISCUSSION

Previous research has introduced various anthropometry tools. In 2015, Galuh Lailatus Annisya developed "Malnutrition Monitoring" employing load cell sensors to weigh babies and display results on a Personal Computer (PC) [24]. However, this tool didn't incorporate height or length parameters for assessing nutritional status. Similarly, in 2017, Retno Dyah Kinanthi designed "The Device for Measuring Weight, Length, and Head Circumference of Infants with Graphical Display" utilizing variable resistors (potentiometers) for length and head circumference detection [25]. Despite its graphical display capability, it lacked the function to save results. Later in 2020, Kinanti Elok Putri introduced "The Weight Measurement Tool for Testing Nutritional Status of Toddlers Using Anthropometry Method" integrating load cell weight sensors and potentiometers. Although this tool could compute nutritional status using z-score calculations on a PC, data accessibility and file-saving were problematic[26].

Building upon prior research, the author enhanced this anthropometry and stunting monitor tool by automatically analyzing the child's nutritional status, establishing a user database on Google Spreadsheet, and incorporating a feature for sharing measurement results via WhatsApp. This feature facilitates timely dissemination of nutritional status information to parents of toddlers and grants healthcare workers access to a shared database via Google Spreadsheets online. The accuracy assessment of the Anthropometry and IoT-based Stunting Monitor tool yielded promising results. It demonstrated a mere 0.017619048 kg average error and 99.82% accuracy in weight measurements, surpassing conventional methods. Similarly, for height measurements, it exhibited a 1.639047619 cm average error and 97.34% accuracy, rivaling traditional meter measurements. Overall, the study concludes that this tool provides highly precise measurements, exceeding the 97.34% accuracy threshold and presenting a viable solution for early stunting detection and monitoring in children, offering valuable insights for healthcare professionals and caregivers.

Nonetheless, the tool's reliance on stable internet connectivity poses limitations. Poor internet connection impedes measurement result display within the application. Moreover, the device's hotspot or Wi-Fi settings must align with its configuration, hindering connectivity with networks having different names or passwords.

In light of these findings, recommendations for future research include exploring alternative connectivity solutions to mitigate internet dependency and enhance user interface flexibility for seamless operation across various network configurations. Additionally, further investigation into the tool's integration with existing healthcare systems could streamline data management and improve accessibility for healthcare professionals. This advancement can significantly benefit communities by providing efficient and accurate monitoring and addressing child stunting, thus contributing to improved child health outcomes.

V. CONCLUSION

From this study, several conclusions can be drawn. First, the analysis of stunting nutritional status in infants can be carried out effectively using the z-score formula by Ministry of Health Regulation No. 2 of 2020 concerning Child Anthropometry Standards. Second, the nutritional status of stunted children can be assessed based on three standard anthropometric indices: age weight (BB/U), height to age (TB/U), and height weight (BB/TB) for toddlers aged 2-5 years. Third, weight measurement can be done accurately using load cell sensors and HX711 modules with a maximum capacity of 25 kilograms, while height measurements can be done using HC-SR04 sensors. Fourth, the use of IoT-based tools facilitates anthropometric tasks, assisting midwives and health workers in recording data, storing, and identifying stunting cases. Finally, simplification of the process of recording and storing data can be achieved through Android platforms such as the Anthropometry application (MIT App Inventor), Google Sheets, and WhatsApp, which are integrated into the device.

These conclusions have significant implications in real-world applications, especially in the context of improving health services and stunting prevention efforts. By using the z-score formula and standard anthropometric index, health services can more efficiently and effectively assess children's nutritional status, enabling early identification of stunting cases. The use of sensor technology and IoT-based tools simplifies and improves measurement accuracy, helping health workers in performing anthropometric tasks more efficiently. The integration of Android platforms such as the Anthropometry app, Google Sheets, and WhatsApp facilitates the process of recording and storing data, making it possible for healthcare workers to quickly access and share relevant information. Thus, the results of this study can contribute significantly to improving stunting prevention efforts and improving the quality of child health services in the community.

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