Accredited rank 4 (SINTA 4), excerpts from the decision of the DITJEN DIKTIRISTEK No. 230/E/KPT/2023

PROTOTYPE OF AN AUTOMATIC HEIGHT AND WEIGHT MEASUREMENT SYSTEM BASED ON Z-SCORES FOR DETERMINING THE NUTRITIONAL STATUS OF TODDLERS

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Abstract

Monitoring the nutritional status of children aged 24-60 months is a crucial aspect of ensuring their growth and development. The commonly used manual methods often have limitations in terms of accuracy and efficiency. This study aims to design and develop a prototype of an automated height and weight measurement system based on Z-Score to accurately and efficiently determine the nutritional status of children. The system is developed using the ESP8266 microcontroller as the control center, integrating an RFID module for child identification, an ultrasonic sensor for height measurement, and a load cell for weight measurement. The measurement data is then processed to generate a Z-Score value, which is displayed on an LCD screen. Based on the test results, the system demonstrates a measurement accuracy of 99.60% for children's height and weight. Additionally, the nutritional status assessment aligns with WHO standards. This system is expected to enhance the effectiveness and efficiency of nutritional monitoring for toddlers.

Keywords: Automated Height and Weight Measurement System; Z-Score; Nutritional Status; Children Aged 24-60 months; WHO Child Growth Standards

Abstrak

Pemantauan status gizi balita usia 24-60 bulan merupakan aspek penting dalam menjaga pertumbuhan dan perkembangan anak. Metode manual yang umum digunakan seringkali memiliki keterbatasan dalam hal akurasi dan efisiensi. Penelitian ini bertujuan untuk merancang dan mengembangkan purwarupa sistem pengukur tinggi dan berat badan otomatis berbasis Z-Score untuk menentukan status gizi balita dengan akurat dan efisien. Sistem ini dikembangkan menggunakan mikrokontroler ESP8266 sebagai pusat kendali, yang mengintegrasikan modul RFID untuk identifikasi balita, sensor ultrasonik untuk pengukuran tinggi badan, dan load cell untuk pengukuran berat badan. Data pengukuran kemudian diolah untuk menghasilkan nilai Z-Score yang ditampilkan pada layar LCD. Berdasarkan hasil pengujian, sistem menunjukkan akurasi pengukuran sebesar 99,60% untuk tinggi dan berat badan anak. Selain itu, penilaian status gizi yang dihasilkan sesuai dengan standar WHO. Sistem ini diharapkan dapat meningkatkan efektivitas dan efisiensi dalam pemantauan status gizi balita.

Kata kunci: Sistem Pengukur Tinggi dan Berat Badan Otomatis; Z-Score; Status Gizi; Anak Usia 24-60 bulan; Standar Pertumbuhan Anak WHO

INTRODUCTION

Toddlers are a group of children aged 0-59 months. During this period, the toddlers require balanced nutritional intake in terms of both quantity and quality to achieve optimal weight and height (Menteri Kesehatan RI, 2020). Body weight and height are important parameters of growth and development of the toddlers (Umiatin et al., 2019). Nutrition plays a crucial role in a child's normal growth and development.

Public health can be measured using indicators, one of which is the nutritional status of toddlers (Anggari et al., 2021). One of the main signs of chronic malnutrition is stunting in toddlers, indicating that the child's body is not receiving sufficient nutrition for growth and development. Stunting is characterized by short stature (Apriningtyas & Kristini, 2019) due to chronic malnutrition and poor appetite (Arini & Faradilah, 2020). Furthermore, stunting is not only a matter of short stature, but is also associated with other health problems such as stunted bone growth, poor weight gain, a weak immune system, and cognitive impairment (Fauziah et al., 2023). Stunted growth can lead to the risk of disease, death, impaired brain and motor development, and poor performance of children in the future. The large number of stunted children in the community indicates that the problem persists (Apriningtyas & Kristini, 2019).

Malnutrition not only stunts growth but also increases the risk of diseases that can disrupt the growth and development process (Zulfiani et al., 2024). Children with normal nutritional status generally exhibit growth in line with their age, have a healthy body, a good appetite, and optimal adaptation to their environment. Conversely, children with abnormal nutritional status are at risk of various limitations, such as stunted growth, weight and height deviations from normal standards, and developmental delays (Gannika, 2023).

Although the prevalence of stunting in Indonesia has decreased from 24.4% in 2021 to 21.6% in 2022, this figure remains high according to data from the Ministry of Health of the Republic of Indonesia (BKPP Kemenkes RI, 2023). Given this situation, monitoring the nutritional status of toddlers is a crucial aspect to support optimal child growth.

Integrated health service post (*pos pelayanan terpadu* [Posyandu]) is a basic health and social service facility organized by the community, for the community (Kusuma, 2022), and guided by health workers from the local community health center (*pusat kesehatan masyarakat* [Puskesmas]), with the main goal of improving the health of mothers and children (Kirana & Gani, 2023), toddlers, the elderly, and people with disabilities. One of the tasks of Posyandu is monitoring the growth of toddlers by measuring their height and weight. This is usually done by measuring height using a stature meter and weighing with an analog or digital scale. The results of the measurements and weighing are then recorded in the officer's notebook.

Previous research were conducted to overcome the limitation of manual process in measurement and weighing aforementioned by providing computer-based or IoT-based automatic measurement and recording system. Various types of devices have been tried to be used as controllers in building automatic toddler height and weight measuring devices, such as those done by (Maulana et al., 2021) using Arduino UNO + ESP8266 for measurement and PC to read and record measurement results. (Firmansyah et al., 2024) using Arduino UNO for measurement but without an automatic recording system, (Ilham et al., 2022) using Arduino UNO with an automatic recording system, and (Sarumaha & Panjaitan, 2025) using Arduino UNO with an ESP8266 WiFi module and measurement data sent to Blynk for further processing. A more sophisticated device has been developed by (Faizal et al., 2023) using 2 x ESP8266 NodeMCU (master and slave) with an RFID system for toddler identification. A more comprehensive system was developed by (Fauzi et al., 2025) using ESP32, with measurement data sent to a web server in real-time. A web-based application is also provided to monitor children's measurement data and nutritional status based on the Z-Score as well as WhatsApp notifications to parents.

(Pratiwi et al., 2024) reviewed several quantitative studies using a systematic review method to examine the development of portable digital height measurements. They searched for journals on the Google Scholar published from 2010 to 2020. The independent variables were microtoise (stature meter) and portable digital measuring instruments. The dependent variable was the difference in the results of measuring height in children under five. They searched for publications in the last 10 years, research in Indonesia and abroad. The results showed a difference in height measurements for toddlers between manual and digital measuring devices, with an error of 0.99%, a measurement difference of 0.2 cm, and a precision and accuracy of >98%.

This research aims to improve the design and development of the system from previous research by combining the main features required from a toddler height and weight measurement system so that it can be used to determine the nutritional status of toddlers aged 24-60 months more accurately. The system supports effective monitoring of toddler nutritional status and accelerates necessary interventions to ensure optimal child growth and development. It will include complete main features but remain affordable so that it can be used by Posyandu officers efficiently. This system is expected to address the limitations of previous research as will be explained in the Results and Discussion section.

P-ISSN: 2656-1743 |E-ISSN: 2656-1735
DOI: https://doi.org/10.34288/jri.v7i4.421
Accredited rank 4 (SINTA 4), excerpts from the decision of the DITJEN DIKTIRISTEK No. 230/E/KPT/2023

RESEARCH METHODS

Approach

This research uses a literature review and systems engineering approach. The literature review was conducted to examine theories related to toddler height and weight measurement, Z-Score calculation methods, and WHO nutritional status standards as a basis for system development.

Based on the results of the literature review, this study then designed and developed a prototype of a microcontroller-based automatic height and weight measurement system to determine the nutritional status of toddlers aged 24-60 months. This research focused on the design, implementation, and testing of the system prototype, which integrates hardware and software into a single functional unit. The use of height sensors, weight sensors (load cells), and an ESP8266 microcontroller were key components in the development of this system. Because this research focuses on the direct development of functional tools, it does not fall into the category of information systems development, which generally focuses on large-scale software development and integration.

Procedure

To illustrate the stages conducted, Figure 1 shows a flowchart of the research.

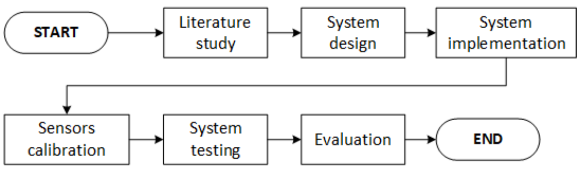

Figure 1. Research method.

The literature review phase involved gathering various relevant references, such as scientific journals, articles, books, WHO standards, and technical documentation related to toddler height and weight measurement systems, Z-Score calculation methods, the operating principles of ultrasonic sensors, load cells, RFID modules, and ESP8266 microcontroller programming. The obtained references were analyzed to understand the advantages and disadvantages of similar systems, determine appropriate Z-Score calculation techniques, and select the appropriate technology to meet the system's automation needs. Based on the analysis, system requirements specifications were developed, covering component selection, measurement accuracy standards, and data processing mechanisms. Next, an initial design framework was developed, consisting of block diagrams, system workflow diagrams, and the basic structure of the calculation algorithm and classification of toddler nutritional status.

The system design phase included hardware and software design. For hardware, an ultrasonic sensor was selected to measure height and a load cell to measure weight. The ESP8266 microcontroller served as the control center, processing the data and integrating it into a database before displaying it on the LCD. Additionally, an RFID module was added for toddler identification, which activates the sensor after the RFID tag is tapped. The software uses an ESP8266 microcontroller programmed using the Arduino IDE with a library to control the sensor and send data to the server. Z-Score calculations are performed on the server using PHP, which is connected to MariaDB to store the data. After processing, the measurement results and nutritional status are displayed on an LCD screen.

The system implementation phase includes integrating the hardware design into a prototype that can function automatically. The system consists of several components, including an ultrasonic sensor for height measurement, a load cell and HX711 module for weight measurement, an RFID module for toddler identification, and an ESP8266 microcontroller as the control center. The system is also equipped with a 12-volt adapter for power supply and an LCD to display the measurement results and nutritional status.

The sensor calibration phase aims to ensure the accuracy of height and weight measurements under various conditions and optimize the device's performance to meet specified standards.

The system testing phase is conducted in a home environment to assess system performance under less controlled conditions. The test involved three toddlers as samples to ensure the system's functionality in measuring height and weight, as well as determining nutritional status. After obtaining the system's measurement results, they were compared with manual instruments, including a height meter and a scale.

Evaluation of the height, weight, and nutritional status measurement results was conducted by comparing the data obtained from the system to WHO standards. This evaluation aimed to assess the level of conformity of the measurement results to these standards and to calculate accuracy and error rates to ensure the system's reliability in determining nutritional status.

Nutritional Status and Z-Score

Nutritional status is a condition resulting from the balance between nutrient intake from food and the body's metabolic needs. Each individual requires different nutritional intakes, depending on their age, gender, daily physical activity, and weight (DitGizi Kemenkes RI, 2018). Nutritional status for toddlers is the nutritional state of children aged 0–59 months, determined using anthropometric methods, based on the Weight-for-Age (W/A), Height-for-Age (H/A), and Weight-for-Height (W/H) indices. W/A is the child's weight achieved at a specific age, while H/A is the child's height achieved at a specific age. W/H is the child's weight compared to their height. These three nutritional status index values are compared to WHO growth standards.

The Z-Score is the deviation of W/H from the normal W/H values according to WHO child growth standards (WHO International, 2025a), (WHO International, 2025b). Table 1 shows WHO child growth standards for boys and Table 2 shows WHO child growth standards for girls. Posyandu can choose one or more indexes, depending on the needs and condition of the toddler being examined.

Table 1. WHO child growth standards for boys.

Weight-for-height BOYS
2 to 5 years (z-scores)
World Health Organization

				Z-scores (weight in kg)						
Height (cm)	L	M	S	-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
65.0	-0.3521	7.4327	0.08217	5.9	6.3	6.9	7.4	8.1	8.8	9.6
65.5	-0.3521	7.5504	0.08214	6.0	6.4	7.0	7.6	8.2	8.9	9.8
66.0	-0.3521	7.6673	0.08212	6.1	6.5	7.1	7.7	8.3	9.1	9.9
66.5	-0.3521	7.7834	0.08212	6.1	6.6	7.2	7.8	8.5	9.2	10.1
67.0	-0.3521	7.8986	0.08213	6.2	6.7	7.3	7.9	8.6	9.4	10.2
67.5	-0.3521	8.0132	0.08214	6.3	6.8	7.4	8.0	8.7	9.5	10.4
68.0	-0.3521	8.1272	0.08217	6.4	6.9	7.5	8.1	8.8	9.6	10.5
68.5	-0.3521	8.2410	0.08221	6.5	7.0	7.6	8.2	9.0	9.8	10.7
69.0	-0.3521	8.3547	0.08226	6.6	7.1	7.7	8.4	9.1	9.9	10.8
69.5	-0.3521	8.4680	0.08231	6.7	7.2	7.8	8.5	9.2	10.0	11.0
70.0	-0.3521	8.5808	0.08237	6.8	7.3	7.9	8.6	9.3	10.2	11.1
70.5	-0.3521	8.6927	0.08243	6.9	7.4	8.0	8.7	9.5	10.3	11.3
71.0	-0.3521	8.8036	0.08250	6.9	7.5	8.1	8.8	9.6	10.4	11.4
71.5	-0.3521	8.9135	0.08257	7.0	7.6	8.2	8.9	9.7	10.6	11.6
72.0	-0.3521	9.0221	0.08264	7.1	7.7	8.3	9.0	9.8	10.7	11.7
72.5	-0.3521	9.1292	0.08272	7.2	7.8	8.4	9.1	9.9	10.8	11.8
73.0	-0.3521	9.2347	0.08278	7.3	7.9	8.5	9.2	10.0	11.0	12.0
73.5	-0.3521	9.3390	0.08285	7.4	7.9	8.6	9.3	10.2	11.1	12.1
74.0	-0.3521	9.4420	0.08292	7.4	8.0	8.7	9.4	10.3	11.2	12.2
74.5	-0.3521	9.5438	0.08298	7.5	8.1	8.8	9.5	10.4	11.3	12.4
75.0	-0.3521	9.6440	0.08303	7.6	8.2	8.9	9.6	10.5	11.4	12.5
75.5	-0.3521	9.7425	0.08308	7.7	8.3	9.0	9.7	10.6	11.6	12.6
76.0	-0.3521	9.8392	0.08312	7.7	8.4	9.1	9.8	10.7	11.7	12.8
76.5	-0.3521	9.9341	0.08315	7.8	8.5	9.2	9.9	10.8	11.8	12.9

WHO Child Growth Standards

The Z-Score value is calculated using the following formula:

$$Z = \frac{x - \mu}{\sigma} \tag{1}$$

where Z is the Z-Score, x is an individual value, μ is a reference median value, and σ is a reference standard deviation.

The method for calculating a toddler's nutritional status using the Z-Score depends on the following two conditions:

1. If the *individual value* measured is **greater** than the *reference median value* for weight/height, then the formula used is:

$$Z = \frac{x - \mu}{upper\ \sigma}$$

$$Z = \frac{x - \mu}{+1\ SD - \mu} \tag{2}$$

2. If the *individual value* measured is **less or equal** than the *reference median value* for weight/height, then the formula used is:

$$Z = \frac{x - \mu}{lower\ \sigma}$$

$$Z = \frac{x - \mu}{\mu - (-1\ SD)} \tag{3}$$

Once the Z-Score has been obtained, it will then be compared to the WHO threshold values to determine the toddler's nutritional status. Table 3 shows the WHO's nutritional status thresholds for children.

Table 2. WHO child growth standards for girls.

Weight-for-height GIRLS
2 to 5 years (z-scores)
World Health Organization

				Z-scores (weight in kg)						
Height (cm)	L	M	S	-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
65.0	-0.3833	7.2402	0.09113	5.6	6.1	6.6	7.2	7.9	8.7	9.7
65.5	-0.3833	7.3523	0.09109	5.7	6.2	6.7	7.4	8.1	8.9	9.8
66.0	-0.3833	7.4630	0.09104	5.8	6.3	6.8	7.5	8.2	9.0	10.0
66.5	-0.3833	7.5724	0.09099	5.8	6.4	6.9	7.6	8.3	9.1	10.1
67.0	-0.3833	7.6806	0.09094	5.9	6.4	7.0	7.7	8.4	9.3	10.2
67.5	-0.3833	7.7874	0.09088	6.0	6.5	7.1	7.8	8.5	9.4	10.4
68.0	-0.3833	7.8930	0.09083	6.1	6.6	7.2	7.9	8.7	9.5	10.5
68.5	-0.3833	7.9976	0.09077	6.2	6.7	7.3	8.0	8.8	9.7	10.7
69.0	-0.3833	8.1012	0.09071	6.3	6.8	7.4	8.1	8.9	9.8	10.8
69.5	-0.3833	8.2039	0.09065	6.3	6.9	7.5	8.2	9.0	9.9	10.9
70.0	-0.3833	8.3058	0.09059	6.4	7.0	7.6	8.3	9.1	10.0	11.1
70.5	-0.3833	8.4071	0.09053	6.5	7.1	7.7	8.4	9.2	10.1	11.2
71.0	-0.3833	8.5078	0.09047	6.6	7.1	7.8	8.5	9.3	10.3	11.3
71.5	-0.3833	8.6078	0.09041	6.7	7.2	7.9	8.6	9.4	10.4	11.5
72.0	-0.3833	8.7070	0.09035	6.7	7.3	8.0	8.7	9.5	10.5	11.6
72.5	-0.3833	8.8053	0.09028	6.8	7.4	8.1	8.8	9.7	10.6	11.7
73.0	-0.3833	8.9025	0.09022	6.9	7.5	8.1	8.9	9.8	10.7	11.8
73.5	-0.3833	8.9983	0.09016	7.0	7.6	8.2	9.0	9.9	10.8	12.0
74.0	-0.3833	9.0928	0.09009	7.0	7.6	8.3	9.1	10.0	11.0	12.1
74.5	-0.3833	9.1862	0.09003	7.1	7.7	8.4	9.2	10.1	11.1	12.2
75.0	-0.3833	9.2786	0.08996	7.2	7.8	8.5	9.3	10.2	11.2	12.3
75.5	-0.3833	9.3703	0.08989	7.2	7.9	8.6	9.4	10.3	11.3	12.5
76.0	-0.3833	9.4617	0.08983	7.3	8.0	8.7	9.5	10.4	11.4	12.6
76.5	-0.3833	9.5533	0.08976	7.4	8.0	8.7	9.6	10.5	11.5	12.7

WHO Child Growth Standards

Table 3. Child nutrition status threshold according to WHO.

Nutritional Status	Threshold (Z-Score)
Malnutrition	< -3 SD
Undernutrition	-3 SD to < -2 SD
Natural Well-being	-2 SD to +1 SD
At Risk of Overnutrition	> +1 SD to +2 SD
Overnutrition	> +2 SD to +3 SD
Obesity	> +3 SD

RESULTS AND DISCUSSION

Hardware Design

Figure 2 shows the block diagram of the Z-Score based automatic height and weight measuring system. This system uses RFID technology to identify toddlers before measuring their height and weight. The RFID Tag stores a UID

JURNAL RISET INFORMATIKA **P-ISSN: 2656-1743 |E-ISSN: 2656-1735**
Vol. 7, No. 4. September 2025 DOI: https://doi.org/10.34288/jri.v7i4.421
Accredited rank 4 (SINTA 4), excerpts from the decision of the DITJEN DIKTIRISTEK No. 230/E/KPT/2023

(Unique Identifier) that will be read by the RFID Reader, then sent to the database via the NodeMCU ESP8266. To measure height, the system utilizes an HC-SR04 ultrasonic sensor that emits ultrasonic waves to the tip of the toddler's head and measures the reflection time to determine the distance between the sensor and the head. Meanwhile, to measure weight, the system uses a Load Cell as a pressure sensor that detects the pressure from the toddler's body. The output in the form of an analog voltage from the Load Cell is amplified and converted into digital data by the HX711 module so that it can be read by the NodeMCU ESP8266. The NodeMCU ESP8266 acts as a processing center that manages data from the RFID, ultrasonic sensor, and Load Cell, then sends the measurement data to the server via a WiFi connection to be stored in the database. The measurement results and analysis of the toddler's nutritional status are displayed directly via a 20x4 LCD. Figure 3 shows a schematic diagram of the system after all components are integrated.

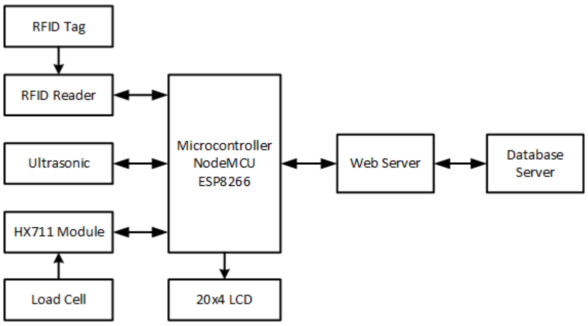

Figure 2. Block diagram of the system.

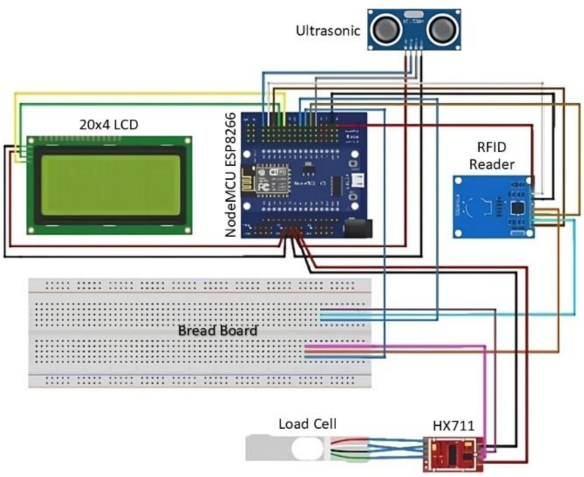

Figure 3. Schematic diagram of the system.

Software Design

The system begins with device initialization, followed by connecting the microcontroller to the internet. If successful, measurements can be taken by tapping the RFID reader. The system checks the data from the RFID card/tag to see if it is registered. If registered, the system will first measure height, followed by a weight measurement. The measurement data, including the card's UID, height, and weight, will be displayed on the LCD, along with the nutritional status.

If the ID card is not registered, the LCD will display "Tag NOT FOUND," meaning the measurement process cannot continue. Toddlers whose data is not registered in the database must be registered first to have their height and weight measured. After a successful measurement, the height and weight data entered into the database will be calculated for nutritional status value and compared to WHO standards to determine whether the toddler is malnourished, undernourished, normal, at risk of overnutrition, overnutrition, or obese. The results will then be displayed on the LCD, formatted with the child's name, age, gender, and nutritional status. The flowchart of these processes is depicted in Figure 4.

System Implementation (Prototype)

The system design is then implemented into a prototype that can be used in practice to measure the height and weight of toddlers and determine their nutritional status. Figure 5 shows the prototype implementation based on the hardware and software design.

Sensors Calibration and System Testing

Calibration of the ultrasonic sensor and load cell sensor was performed to ensure the accuracy of height and weight measurements under various conditions. Calibration was performed by comparing the sensor measurements with those of calibrated manual instruments. The ultrasonic height measurement instrument (H-Sys) was calibrated with a Kenmaster 1023-008 5-meter tape measure (H-Man). The weight measurement instrument (W-Sys), using a load cell with an HX711 module, was calibrated with a Troodon digital scale (W-Man). The differences in measurement results between the two sensors and the calibration instruments were insignificant, indicating that measurements using the developed instrument were sufficiently accurate and could be considered a suitable replacement for manual measurement.

Table 4 shows a comparison of measurement results between the system and the manual calibration instruments for toddlers of different genders and ages.

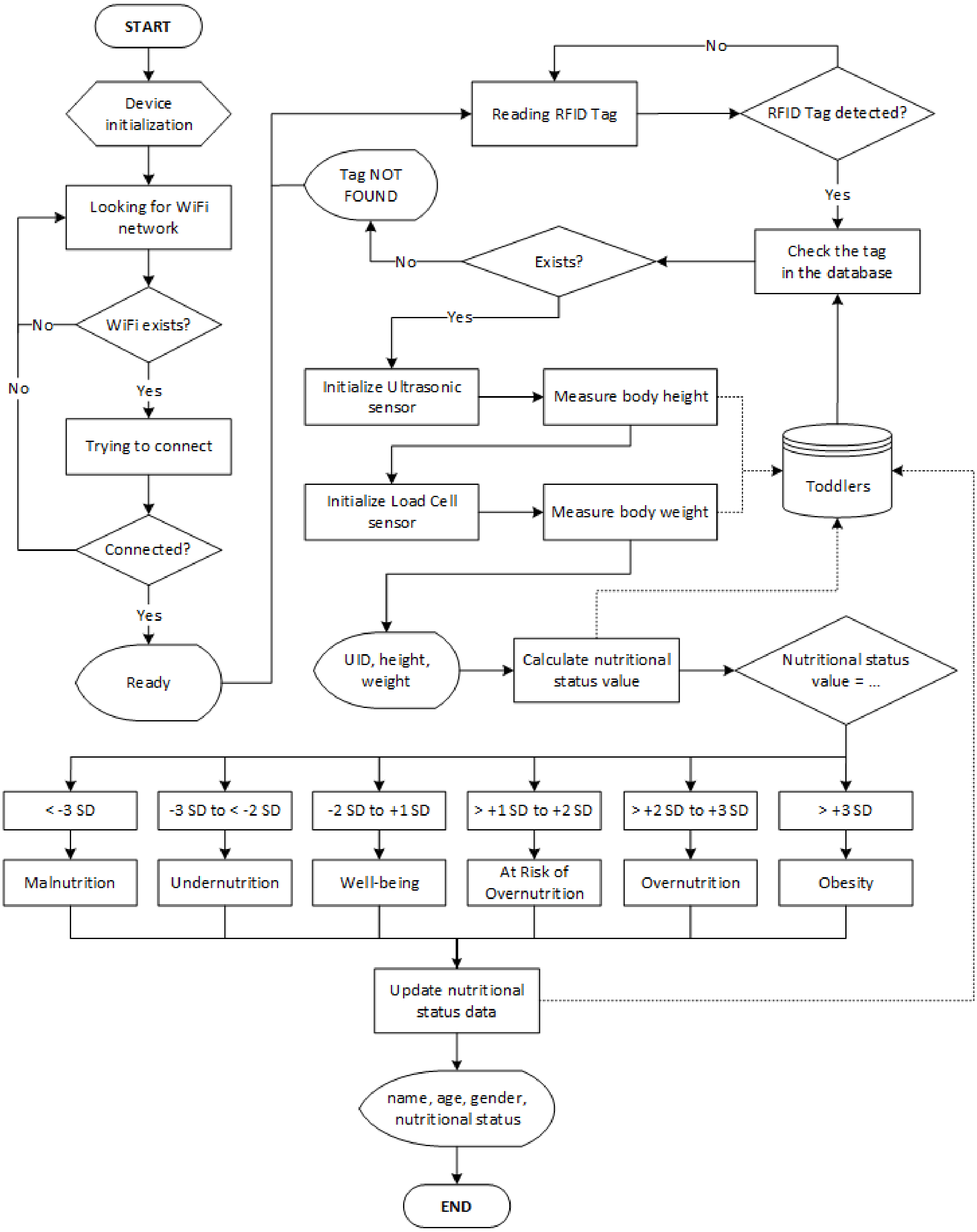

Figure 4. Flowchart of the system.

P-ISSN: 2656-1743 |E-ISSN: 2656-1735
DOI: https://doi.org/10.34288/jri.v7i4.421
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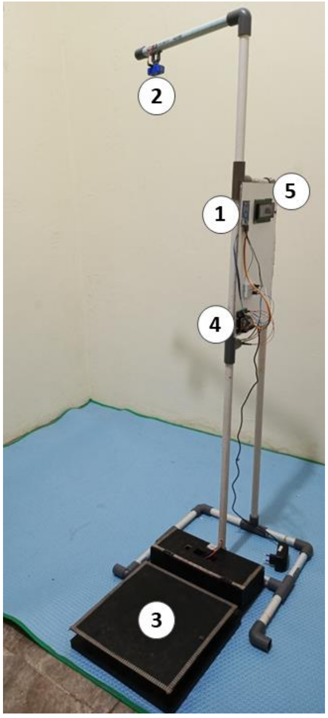

Figure 5. Prototype of the system. Notes: (1) RFID Reader, (2) Ultrasonic sensor, (3) Load Cell sensor, (4) NodeMCU ESP8266, and (5) 20x4 LCD.

Table 4. Comparison of measurement results between the system and the manual calibration instruments.

No	Gen-der	Age (month)	H-Man (cm)	H-Sys (cm)	W-Man (kg)	W-Sys (kg)
1	F	57	112	112	17.65	17.76
2	M	51	114	114	17.30	17.27
3	F	27	87	87	10.60	10.77

Evaluation

The measurement results as shown in Table 4 are then used to calculate the system's accuracy. The accuracy value is a percentage comparison between the measurements made using the system and the manual measurements using calibrated instruments. The results are presented in Table 5 and Table 6.

Table 5. Error and accuracy of the height measurement.

No	Height Manual (cm)	Height System (cm)	Error (%)	Accuracy (%)
1	112	112	0	100
2	114	114	0	100
3	87	87	0	100
			Average	100

Table 6. Error and accuracy of the weight measurement.

No	Weight Manual (kg)	Weight System (cm)	Error (%)	Accuracy (%)
1	17.65	17.76	0.62	99.38
2	17.30	17.27	0.17	99.83
3	10.60	10.77	1.60	98.40
			Average	99.20

Based on average values in Table 5 and Table 6, then the overall accuracy can be obtained as:

$$Total\ accuracy = \frac{100\% + 99.20\%}{2} = 99.60\%$$

A total accuracy of 99.60% indicates that the developed system can effectively measure the height and weight of toddlers. It even achieved perfect accuracy (100%) for height measurements.

Discussion

This is a minimal yet complete system to support the work of a Posyandu officer in recording the height and weight of toddlers automatically. This system has complete innovations and basic features, which consist of: (1) the use of RFID as a toddler ID. Simply attach the RFID to start the height and weight measurement process; (2) the use of a Microcontroller instead of an Arduino+PC as a system controller so that it requires much cheaper costs; (3) calculation of toddler nutritional status according to WHO standards; and (4) automatic saving of measurement data to the cloud storage.

This research addresses the limitations of previous research, such as that by (Maulana et al., 2021), which still relied on PCs to access measurement results and did not include the nutritional status of toddlers. Unlike the research by (Gunawan & Ash Shofar, 2018), which was limited to a web-based application without automated physical measurements, this study integrates physical sensors with Z-Score calculations and provides direct access to results. Furthermore, this research also developed a system that complies with WHO standards, unlike the research by (Prayogie et al., 2022) which only relied on body mass index (BMI) measurements.

The research such as conducted by (Maulana et al., 2021), (Sarumaha & Panjaitan, 2025), and (Faizal et al., 2023) used more than one microcontroller for the system to run, making it inefficient in terms of cost and power, although

(Faizal et al., 2023) has successfully attached an RFID system to the system for toddler identification. (Firmansyah et al., 2024) and (Ilham et al., 2022) have successfully used only an Arduino UNO for the measurement system. However, their systems lacked an internet connection module to store measurement data to cloud storage and lacked features for toddler identification and nutritional status calculation. The most comprehensive system currently available is the one developed by (Fauzi et al., 2025), but it lacks a toddler identification system. To identify a toddler, the operator should enter the hard-coded ID of the toddler manually.

The accuracy obtained from the experiment yields a value of 99.60%. This result demonstrates high agreement with the results obtained from the literature review conducted by (Pratiwi et al., 2024). This accuracy value is the highest compared to previous research to date.

CONCLUSIONS AND SUGGESTIONS

Conclusion

An automatic Z-Score-based height and weight measurement system for toddlers aged 24–60 months has been successfully designed and developed. This system is capable of automatically measuring height and weight and calculating Z-Score values to determine the nutritional status of toddlers based on WHO standards with 99.60% accuracy. This system can support the process of monitoring toddler nutritional status more effectively and efficiently. With fast and accurate measurement results, this system can expedite the decision-making process regarding nutritional interventions needed to support optimal child growth and development.

Suggestion

Suggestions for improvement of this research in the future include increasing the number of trials under various scenarios and environmental conditions to obtain more representative test results. This is necessary to ensure the system is thoroughly tested and can be upgraded from a prototype to a ready-to-use product. The accuracy of weighing using a load cell sensor can be further improved by refining the mock-up design or the device's supporting structure. These improvements aim to ensure the stability of the weighing device's base and minimize potential technical errors during the measurement process. Furthermore, developing an information system integrated with a measurement results database would be helpful in simplifying the process of monitoring and analyzing toddlers' nutritional status in real time.

This system could be equipped with automatic reporting features, data visualization, and a history of toddler development displayed in the form of a web-based or mobile application. As a further development, the system could also be equipped with a nutritional intake recommendation feature tailored to the toddler's nutritional status. This feature aims to provide guidance to parents or health professionals in determining the appropriate diet and nutritional intake according to the toddler's needs.

REFERENCES

Anggari, A. A. I. I., Suyasa, I. G. P. D., & Wulandari, I. A. (2021). Gambaran Kunjungan Balita ke Posyandu dan Status Gizi Balita Pada Masa Pandemi Covid-19 di Desa Buahan Kaja Kabupaten Gianyar Tahun 2020. *Jurnal Riset Kesehatan Nasional*, *5*(2), 126–130. https://doi.org/10.37294/jrkn.v5i2.338

Apriningtyas, V. N., & Kristini, T. D. (2019). Faktor Prenatal yang Berhubungan dengan Kejadian Stunting Anak Usia 6-24 Bulan. *Jurnal Kesehatan Masyarakat Indonesia*, *14*(2), 13–17. https://doi.org/10.26714/jkmi.14.2.2019.13-17

Arini, D., & Faradilah, I. (2020). The Incidence of Stunting and the Frequency and Duration of Diarrhea in Toddler. *Kemas*, *16*(2), 233–240. https://doi.org/10.15294/kemas.v16i2.20032

BKPP Kemenkes RI. (2023, January 25). *Prevalensi Stunting di Indonesia Turun ke 21,6% dari 24,4%*. Website Kemenkes RI. https://kemkes.go.id/id/prevalensi-stunting-di-indonesia-turun-ke-216-dari-244

DitGizi Kemenkes RI. (2018). *Hasil Pemantauan Status Gizi (PSG) Tahun 2017*. https://sehatnegeriku.kemkes.go.id/wpcontent/uploads/2018/01/Buku-Saku-Nasional-PSG-2017-Cetak-1.pdf

Faizal, Moch., Sulistiyowati, I., Jamaaluddin, J., & Anshory, I. (2023). Design of a Height and Weight Measurement Tool for Toddlers at Spreadsheet-Based Posyandu. *JEEE-U (Journal of Electrical and Electronic Engineering-UMSIDA)*, *7*(2), 163–175. https://doi.org/10.21070/jeeeu.v7i2.1677

Fauzi, S. W., Sitti Nurfebruary, N., Ula, M., Nisa, F., & Ikhwani, M. (2025). Perancangan Alat Pengukuran Tinggi dan Berat Badan Berbasis Internet of Things Untuk Deteksi Stunting pada Bayi Usia 1-12 Bulan di Posyandu (Studi Kasus Gampong Rayeuk Kareung). *Journal of Science and Social Research*, *8*(3), 5189–5195. https://doi.org/10.54314/jssr.v8i3.3969

Fauziah, J., Trisnawati, K. D., Rini, K. P. S., & Putri, S. U. (2023). Stunting: Penyebab, Gejala, dan Pencegahan. *Jurnal Parenting Dan Anak*, *1*(2), 11. https://doi.org/10.47134/jpa.v1i2.220

Firmansyah, D. A., Saragih, I. M. L., & Yasri, B. (2024). Purwarupa Alat Ukur Bobot dan Tinggi Badan Batita Berbasis Arduino. *Journal of Electrical Engineering*, *1*(2), 1–17. https://doi.org/10.47134/jte.v1i2.2965

Gannika, L. (2023). Hubungan Status Gizi dengan Tumbuh Kembang Pada Anak Usia 1-5 Tahun: Literature Review. *Ners*, *7*(1), 668–674. https://doi.org/10.31004/jn.v7i1.14198

Gunawan, & Ash Shofar, I. N. (2018). Penentuan Status Gizi Balita Berbasis Web Menggunakan Metode Z-Score. *Infotronik*, *3*(2), 120–125. https://doi.org/10.32897/infotronik.2018.3.2.111

Ilham, Yulianto, R., & Amiruddin, A. (2022). Sistem Pengukur Berat Badan dan Tinggi Badan dengan Pencatatan Otomatis Berbasis Internet of Things. *Journal of Natural Science and Technology Adpertisi*, *2*(2), 24–32. https://doi.org/10.62728/jnsta.v2i2.342

Kirana, S. Z., & Gani, A. (2023). Peran Pos Pelayanan Terpadu (Posyandu) dalam Meningkatkan Kesehatan Ibu Hamil di Indonesia. *Jurnal Cahaya Mandalika*, *4*(2), 171–180. https://doi.org/10.36312/jcm.v4i2.1518

Kusuma, A. N. (2022). The Presence of Posyandu as an Approach in Improving Health Development in the Community. *Jurnal Eduhealt*, *13*(01), 137–146. http://ejournal.seaninstitute.or.id/index.php/healt

Maulana, D. R., Rohana, T., & Pratama, A. R. (2021). Alat Ukur dan Pencatat Otomatis Tinggi dan Berat Badan Balita Berbasis Arduino. *Scientific Student Journal for Information, Technology and Science*, *2*(1), 191–196.

Menteri Kesehatan RI. (2020). *Permenkes Nomor 2 Tahun 2020 Tentang Standar Antropometri Anak*. https://paralegal.id/peraturan/peraturan-menteri-kesehatan-nomor-2-tahun-2020/

Pratiwi, N., Jaladri, I., Gitning, M., Andini Jurusan Gizi, L., & Kemenkes Pontianak, P. (2024). Kajian Literatur Tentang Perkembangan Portabel Digital Dalam Mengukur Tinggi Badan Pada Balita. *Media Gizi Khatulistiwa*, *1*, 1–6. https://doi.org/10.2804/mgk.1811.1016

Prayogie, A., Fauziah, A., & Syamsul. (2022). Alat Pengukur Tinggi dan Berat Badan Otomatis Menggunakan Sensor Ultrasonic dan LoadCell Berbasis Internet of Things. *TEKTRO*, *6*(1), 38–43. https://doi.org/10.30811/tektro.v6i1.3214

Sarumaha, A. L., & Panjaitan, C. E. (2025). Pengukuran Tinggi Badan Dan Berat Badan Anak-Anak Berbasis IOT Menggunakan Arduino UNO. *Informatic Technique Journal*, *2*(2), 43–

55. https://upu-journal.potensi-utama.org/index.php/itjournal/article/view/1122

Umiatin, U., Erlandita, S. M., & Indrasari, W. (2019). Design baby mass and height monitoring system based on Arduino and Android application. *AIP Conference Proceedings*, *2169*. https://doi.org/10.1063/1.5132663

WHO International. (2025a). *Weight-for-height BOYS 2 to 5 years (z-scores)*. https://cdn.who.int/media/docs/default-source/child-growth/child-growth-standards/indicators/weight-for-length-height/wfh-boys-2-5-zscores.pdf?sfvrsn=66c3e6fe_9

WHO International. (2025b). *Weight-for-height GIRLS 2 to 5 years (z-scores)*. https://cdn.who.int/media/docs/default-source/child-growth/child-growth-standards/indicators/weight-for-length-height/wfh-girls-2-5-zscores.pdf?sfvrsn=3dc8f085_9

Zulfiani, E., Layinatul Fuadah, L., Ilmu Kesehatan, F., & Islam Al-Ihya Kuningan, U. (2024). Peran Gizi dan Ahli Gizi Dalam Upaya Pembangunan Nasional di Indonesia. *JUSINDO*, *6*(1), 211–217. https://doi.org/10.59141/jsi.v6i01.76