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An IoT-based Baby Scales for Stunting Monitoring in Indonesia

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ABSTRACT The Indonesian government has tried to do prevention stunting case by monitoring and recording the toddlers growth. The problems are the process of recording and entering toddler growth data is still done manually. This is not effective if done over a large area such as in Indonesia because it takes a long time to collect data and has a large possibility of recording errors. The aim of this research is to design an IoT-based baby scale by adding Node MCU ESP32 in to digital baby scales; so the data read by the scales recorded directly in the central data base. The scales are connected to the data base and web page via a WiFi network. The measurement data will be processed in the cloud to obtain a nutritional status classification. It makes the process of determining nutritional status faster. Based on the research conducted, the use of IoT-based baby scales can simplify the process of measuring toddlers' weight and height. The results of unit testing show that the tool is running well with the level of accuracy are 0,3% still within tolerance limits. The next research is expected to add location features, resumes per area and improve access levels on web pages for data security.

INDEX TERMS Stunting, Baby scales, IoT, Stunting monitoring.

I. INTRODUCTION

One of the social problems in the health sector that is currently occurring is the high prevalence of stunting cases in Indonesia. Stunting is defined as a child's condition with a Z-score for height for age less than -2 standard deviations [1]. Stunting is an important problem, that potentially give negative impact to child development, quality of life and future of these stunted children. Stunting causes high morbidity and mortality such as life-theatening complications during birthing, increased infant mortality rates, reduced cognitive performance, poor intelligent quotients, emergence of chronic desease, reduced production capacity in adulthood, with loses in economic growth and social development of the country[2], [3]. Stunting in Indonesia has become a national issue, with a prevalence in children under five years of 31%, still higher than the normal WHO standard of 20%. It shows that progress in reduce and managing childhood stunting has been slow over the past decade[3]. Child stunting is associated with the following determinants in Indonesia are male sex, premature birth, short birth length, nonexclusive breastfeeding for the first 6 months, short maternal heigth, low maternal education, low household socio-economic status, living in a household with unimproved latrines and untreated drinking water, poor access to healthcare, and living in rural area[4], [5].

Various efforts have been made by the government to reduce prevalence of stunting cases in Indonesia. Stunting convergence management framework to accelerating stunting reduction through system integration based on regional governance are leadership and staff[6], stunting analysis, digitizig stunting data, the readiness of stunting data management and open government [7], [8]. In other studies, stunting case management can be started from early detection of stunting cases from newborn, that requires inter-sectoral collaboration and programs[9]. Early detection is carried out by anthropometric measurements including body weight, height, head circumference and arm circumference to get Z-score and classify them into certain categories [9], [10]. The anthropometric measurement process is critical because measurement accuracy is an essential indicator to obtain accurate and high-quality data; moreover, errors in these measurements can affect interpretation. Inappropriate

anthropometric measurements can lead to misclassification of nutritional status, intervention planning, and referrals[11].
The problems are the process of recording and entering toddler growth data is still done manually. Anthropometric measurements were carried out at the posyandu and data were collected through the puskesmas to the health service level which covers a wider area. Recording measurement results using the KMS book. It is not uncommon for KMS books to be lost, scattered or damaged. This is not effective if done over a large area such as in Indonesia because it takes a long time to collect data and has a large possibility of recording errors.
How to make an automatic baby scale that can simplify and speed up the measurement and reporting process is a fundamental question in this research. A new community health service method for recording and monitoring the nutritional status of infants and toddlers based IoT is presented in this paper. Modifications are made by adding IoT technology to baby scales, so the data collection process by telemetry will be faster and the percentage of human error can be reduced[12], [13]. Telemetry is the process of measuring the parameters of an object (object, space, natural conditions) whose results are sent to another place via cable or wirelessly. Telemetry is expected to provide convenience in measurement, monitoring and reduce barriers to obtaining information[14]. One of the technologies that supports the telemetry process is Internet of Things technology (IoT). The IoT is a technology that innovates surrounding objects, gadgets, databases, applications with the internet so that dialy activities become easier and more efficient [15], [16]. The basic IoT system consist of hardware/physical things include sensors, internet connection and cloud data center; which the interaction between hardware that are connected automatically without user intervention and at any distance, the user only serves as a regulator or supervisor[17]–[20]. Lack of access to medical resources, growth of the elderly population with cronic diseases and their needs for remote monitoring, an incrase in medical cost, and the desire for the telemedine in developing countries, make the IoT an interesting subject in healthcare system [21]–[26], specially during Covid-19 pandemic[27]–[30] . The factor that led to the merging of IoT and Cloud Data Center are cloud provides unlimited, low-cost and on-demand storage capacity, IoT system cloud perform real-time processing of data thus facilitating highly responsive applications, monitoring and control things on a real-time basis through remote locations, any time any where availability of resources, various devices can connect and interact with cloud[18], [31]–[34].

II. MATERIAL AND METHODS

The design of baby scales has two parts, hardware and software. In the hardware section, digital baby scales are modified with the addition Node MCU ESP 32 which allows baby scales to be connected to the internet via a wifi network so the measurenment data from the posyandu can be directly conveyed to the data center. In the software section, a web page are create to manage the results of anthropometric measurements for toddlers and another personal data. The stunting toddler classification is also added to the toddler anthropometric measurement web page.

A. THE DIAGRAM BLOCK

To implement a system of baby scales with IoT for stunting monitoring, research uses the proposed equipment in baby scales as depicted in FIGURE 1 and FIGURE 2, which included a modul power supply, sensors, a modul controller, and touchscreen LCD.

Modifications were made by adding the ESP 32 module to digital baby scales. The ESP32 is a family of low-cost, low-power system on-chip microcontrollers with Wi-Fi and Bluetooth capabilities and a highly integrated structure powered by a Tensilica Xtensa LX6 dual-core microprocessor. Loadcell sensor and HX711 are components for measuring body weight; while the encoder module is a component for measuring the toddler's height. Baby scales are also equipped with an LCD to display the interface. The data will also be stored in the cloud data center and can be viewed on the web page.

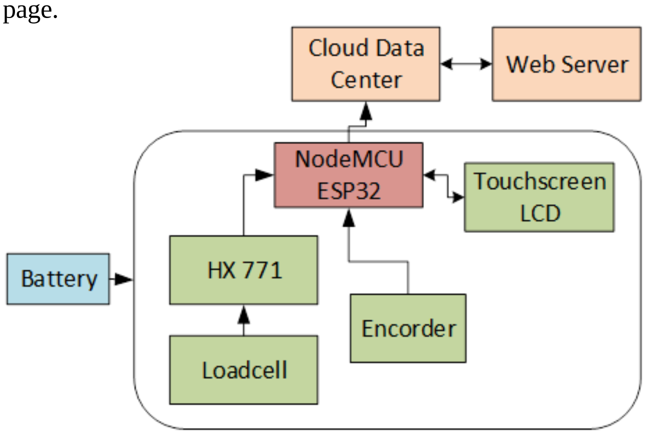

FIGURE 1. The diagram block of the system circuit

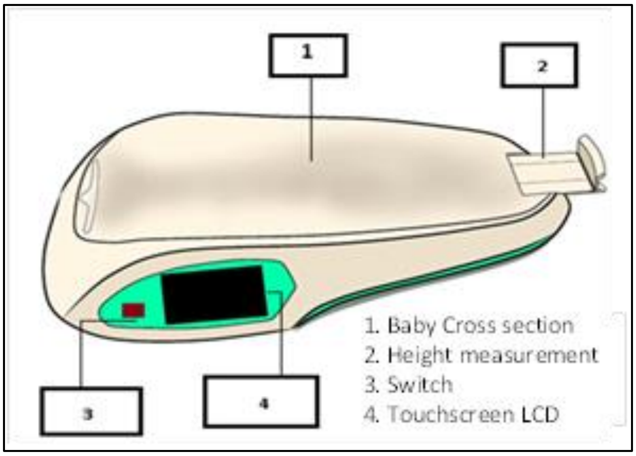

FIGURE 2. Design of IoT-based baby scales

B. WORK FLOW DIAGRAM

The work flow of IoT-based baby scales can be seen in FIGURE 3. Baby scales require calibration at the first measurement after the instrument is switched on. For subsequent measurements there is no need for the calibration process again. Data on the baby's name, ID number, baby's date of birth, and gender need to be entered in the IoT-based baby scales system. The scales are equipped with an edit menu and a save menu for editing and saving child identity data. Measurement history can also be deleted using the delete menu.

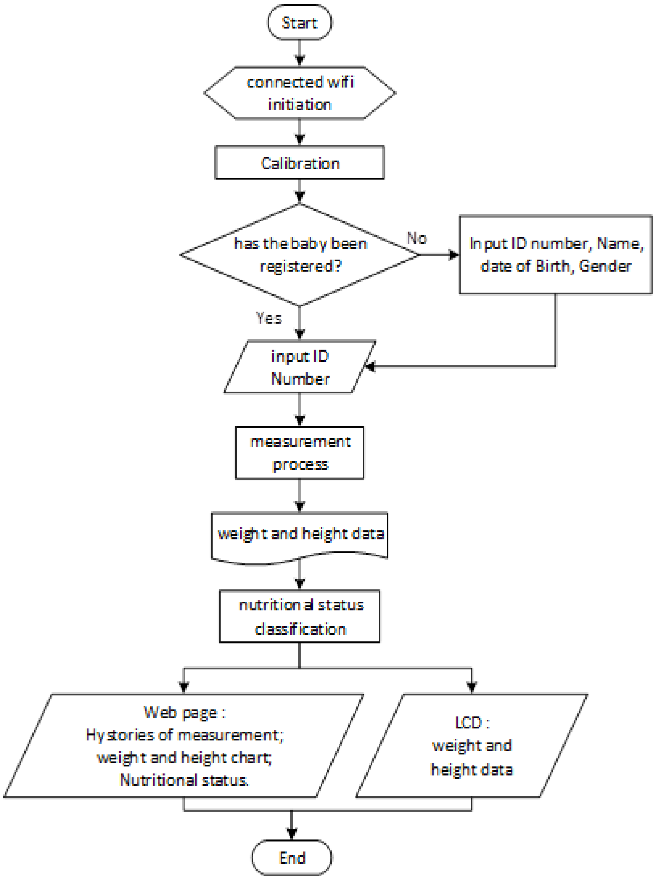

FIGURE 3. The flowchart of the system

The nutritional status information system for children was built using the PHP programming language and MySQL database. Assessment of children's nutritional status is carried out by comparing the results of measurements of weight and length/height with the Children's Anthropometric Standards. The classification of nutritional status assessment based on the Anthropometric Index corresponds to the category of nutritional status in the WHO Child Growth Standards for children aged 0-5 years. Body Weight Index for Length/Height (BB/PB or BB/TB) This BB/PB or BB/TB index illustrates whether a child's weight is appropriate for the growth in length/height. This index can be used to identify wasted, severely wasted children and children who are possible risk of overweight. Table 1 shows the index of weight according to height according to the Minister of Health Regulation, 2020 (TABLE 1).

TABLE 1

Index of weight according to height for children ages 0-60 month

Classifications of nutritional status	Z-Score
Severely Wasted	<- 3 SD
Wasted	-3 SD until <-2 SD
Normal	-2 SD until +1 SD
Possible risk or overweight	> + 1 SD until + 2 SD
Overweight	> + 2 SD until + 3 SD
Obese	> + 3 SD

The nutritional status classification pseudocode is as follows.

weight, height, SD : float
read (weight)
read (height)
SD = weight/height
if SD = 0 then write "Error" else
if SD < - 3 then write "Gizi Buruk" else
if SD < -2 then write "Gizi Kurang" else
if SD < 1 then write "Gizi Baik" else
if SD < 2 then write "Beresiko Gizi Lebih" else
if SD < 3 then write "Gizi Lebih" else
if SD > 3 then write "Obesitas"
end if

III. RESULT

In this section, the implementation and working of the system baby scales in laboratory scenario for unit testing are explained. Unit testing is carried out to ensure the function of all features is running well and the accuracy of the measurement results is the same as the scales on the market. The complete process of measuring by IoT-based baby scales is explained in the following process sequence:

a) Step 1 : Turn on the baby scales and connect to the wifi network.
b) Step 2 : Then calibrate the baby scales. Don't forget to save the calibration settings so that the measured data is accurate.
c) Step 3 : Input data name, date of birth, gender and ID number for a new measurement; then save and return to the main menu. skip this step if the baby to be measured is already registered.
d) Step 4 : Call back using the id number or name and take weight and height measurements according to the baby's identity.
e) Step 5 : The measurement results will be displayed on the LCD and stored in the cloud data center which can be accessed via a web page. The display on the web page and LCD can be seen in Figures 4 (a), (b), (c), (d) and Figure 5.

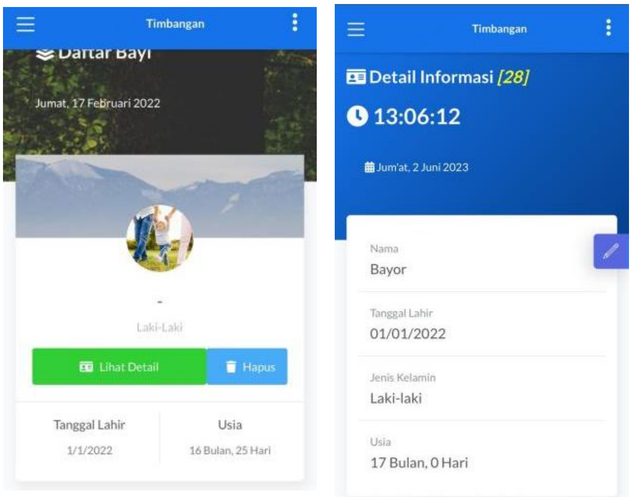

FIGURE 4 (a). **The display of baby's information on the webpage**

FIGURE 4 (d). **The display of nutrition classification on the webpage**

FIGURE 4 (b). **The display of the result on the webpage**

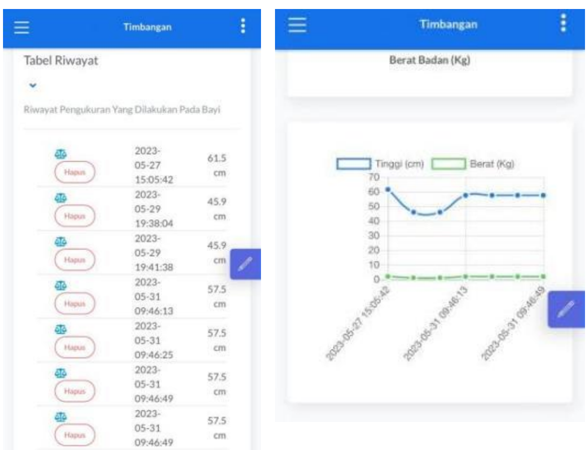

FIGURE 4 (c). **The display of history on the webpage**

Figure 5. **The LCD's display**

IV. UNIT TESTING

There are 3 types of tests carried out on this IoT-based baby scales. The first is a function test to find out all the features of the tool are running properly, the results are listed in TABLE 2.

TABLE 2

The result of unit function test

No	Feature	Result
1	Login and connect wifi	running well
2	Self calibration	running well
3	Input baby's identity from the LCD	running well
4	Displays baby's identity on the LCD	running well
5	Displays measurement results on the LCD	running well
6	Edit menu of baby's identity from the LCD	running well
7	Delete menu of baby's identity from the LCD	running well
8	Displays baby's identity on the web page	running well
9	Displays measurement results on the web page	running well
10	Displays graphic results on the web page	running well
11	Displays hystorical results on the web page	running well
12	Edit menu of baby's identity from the web page	running well
13	Delete menu of baby's identity and result from the web page	running well

The second is a test of the accuracy of the loadcell sensor in measuring body weight using calibrated weights, the results can be seen in TABLE 3.

TABLE 3
The result of the accuracy of loadcell test

No.	Load	I	II	III	Mean	% error
1.	1 kg	1,03	1,03	1,03	1,03	0,3 %
2.	2 kg	2,07	2,07	2,07	2,07	0,3 %
3.	3 kg	3,10	3,10	3,10	3,10	0,3 %
4.	4 kg	4,13	4,13	4,13	4,13	0,3 %
5.	5 kg	5,16	5,16	5,16	5,16	0,3 %
6.	6 kg	6,20	6,20	6,20	6,20	0,3 %
7.	7 kg	7,23	7,23	7,23	7,23	0,3 %
8.	8 kg	8,26	8,26	8,26	8,26	0,3 %
9.	9 kg	9,30	9,30	9,30	9,30	0,3 %
10.	10 kg	10,33	10,33	10,33	10,33	0,3 %
11.	15 kg	15,50	15,50	15,50	15,50	0,3 %
12.	20 kg	20,68	20,68	20,68	20,68	0,3 %

The third is the accuracy test of the encoder module for measuring body height using a calibrated ruler, the results are shown in TABLE 4.

TABLE 4
The Result of the accuracy of encoder test

No.	Standard Ruler Reading (cm)	I (cm)	II (cm)	III (cm)	Mean (cm)	% error
1.	46	46	46	46	46	0 %
2.	50	51,23	51,23	51,23	51,23	0,02 %
3.	60	61,8	61,73	61,73	61,75	0,02 %
4.	70	72,26	72,66	72,40	72,44	0,03 %
5.	80	82,8	82,93	83,03	82,92	0,03 %

V. DISCUSSION

From the function test performed it is known that the baby scales runs well. The accuracy of the tool is still within the tolerance threshold. Measurement results will produce primary data that is accurate and can be processed for other needs. What is interesting in this research is that the measurement results can be displayed graphically. This makes it easier to read the measurement history for officers who are familiar with KMS reports. It also can be viewed at any time anywhere. This makes it easier for health workers to monitor the development of the nutritional status of toddlers in their area. Recording of weight and height is also automatically recorded to the data center so that recording errors due to human errors do not occur again. The risk because the KMS book is lost or not carried is also zero because the recording process is automatic.

It would be better if some features were further developed to support the use of this tool on the end user side, such as adding measurement locations and residential addresses, so the percentage of stunted toddlers are in that area can be seen from the data. Data on the percentage of stunting under five in an area can be the basis for formulating policies in the management of stunting prevention. Access levels on web pages also need to be added to maintain the confidentiality of personal data.

V. CONCLUSIONS

Based on the research conducted, it can be seen that the use of IoT-based baby scales can simplify the process of measuring toddlers' weight and height. A feature that displays a child's nutritional status makes the process of determining nutritional status faster. The results of unit testing show that the tool is running well with the level of accuracy still within tolerance limits. The next research is expected to add location features, resumes per area and improve access levels on web pages.

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