

EARLY DETECTION OF STUNTING AND USER SATISFACTION: AN OVERVIEW OF ANTHROPOMETRIC MEASUREMENT IN INDONESIAN TODDLERS

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Abstract. Cadres and health workers are considered inaccurately measuring toddler height and weight in primary healthcare centers (PHC). Less systematic weighing techniques due to non-standard equipment and various types are the common issue causing this phenomenon. This study developed anthropometric tools for early detecting stunting and measuring user satisfaction. The tools were created using an application system with a microcontroller and an android-based Arduino device embedded. This study used the waterfall method to early detect stunting, and questionnaire was distributed to collect data on user satisfaction. Sample unit for data input was toddlers, and nutritional status and recommendations for toddler meal schedules were the final outputs. All detection systems used sensors that were programmed to allow cadres and health workers to easily identify nutritional status, records, and reports. The score percentage of user satisfaction ranges from 87% to 90%, the application features will be considered useful and easy to use, operate and recognize according to user needs, as well as complete with a well-run chat feature and tracking. The experts also perceived the systems provided understandable information. They stated the tools were helpful for cadres and health workers in PHC and health integrated posts in Indonesia.

Keywords: anthropometry, android, nutritional status, stunting, user satisfaction

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INTRODUCTION

The double burden of malnutrition (DBM) is characterized by the coexistence of undernutrition, overweight, and obesity. Globally, around 149.2 million children under 5 suffered from stunting (low height-for-age) in 2020, 45.4 million were affected by wasting (low weight-for-height), and 38.9 million with overweight (UNICEF/WHO/World Bank, 2021).

Based on the current child health issue, the 2017-2045 National Research Master Plan in Health and Drug Research focuses on the application of nutrition development technology (Ministry of Research Technology and Higher Education, 2017). This master plan is subjected to overcome stunting in Indonesia, a condition in which a child's height is below the average. Based on anthropometric standards, stunting is diagnosed based on the Z-score indicator for height for age. If the Z-score for height by age is smaller than -2 standard deviation, the child is classified as stunted. The main cause of stunting is poor nutritional quality from pregnancy until two years of child life (first 1,000 days of life) (Djauhari, 2017). The prevalence of stunting in children under five in Indonesia in 2013 reached 37.2% (MOH RI, 2013), but it fell to 30.8% in 2018 which was above the WHO's stunting prevalence threshold of 20% (MOH RI, 2019). Research carried out in Indonesia in 2018 found the prevalence of stunting in children younger than 24 months of age was 29.9%. A subsequent study found that in some locations stunting rates among children run as high as 42% (UNICEF, 2020). The prevalence of stunting in children under five in Indonesia is the second largest at 43.8% in Southeast Asia after Laos (BAPPENAS and UNICEF, 2017).

The impact of stunting may be worse on child productivity in adulthood. They might have difficulty in learning to read, imperfect growth and development, low motor skills and productivity, and a higher risk of suffering from non-communicable diseases (Widanti, 2017). Meanwhile, stunting has the negative impacts on women, such as perinatal mortality and a risk of giving birth to stunted children.

The government has formed the National Team for the Acceleration of Poverty Reduction to determine 100 priority districts/cities with stunting cases and Jember Regency was included in those 100 priorities (National Team for the Acceleration of Poverty Reduction, 2017). To execute stunting reduction plan, health workers have to possess detection skills. However, some facts show that a lot of health workers and cadres are not able to perform accurate anthropometric measurement of nutritional status in PHC, toddler age, height, and weight due to non-standard and various types of equipment (Suyatno, 2017).

Errors in determining toddler age lead to overcalculation of the actual age. The incidence of age overcalculation which reached 51.9% may result in increasing miscalculated number of children with undernutrition. At worst, undercalculation of age might also lead to misinterpretation of the number of children with nutritional problems. Consequently, the actual number of stunting incidents never reached conclusion, and some child groups might not deserve treatment properly. One of the existing stunting detection tools is the Wall Growth Chart, which was tested for sensitivity by Sinaga *et al* (2018).

Additionally, in 2019, innovations in height growth detection were disseminated using growth mats. Nonetheless, health workers who want to use growth mats require special training to make the measurements accurate. Thus, it is necessary to have an easier and more practical detection system based on the Android operating system to make four stages of stunting diagnostics more effective (measurement, reporting, data entry and diagnosis determination).

MATERIALS AND METHODS

Materials

The research tools and materials included Arduino Nano microcontroller ATmega, bluetooth HC-05 (Atmel, San Jose, CA), 20X4 LCD circuit (Hua Xian Jing, Guangdong, PR China), smartphone android (Xiaomi, Beijing, PR China), load cell HX711 (Kuangshun Electronic Limited, Shenzhen, PR China), ultrasonic sensor HC-SR04 (Guangzhou Eagle Electronic Company, Guangzhou, PR China), ds18b20 sensor, and step-down module LM2596 (Shenzhen Jin Da Peng Tec, Shenzhen, PR China).

Methods

This study used a waterfall design which is commonly used by several researchers in Indonesia to solve problems related to the development of simple institutional systems. This study also referred to the results of previous research about the use of the waterfall method to manage data of internal quality assurance in universities (Pawan *et al*, 2021). The waterfall method is a process of making and changing systems, models, and methodologies that include five stages: analysis identification, design, implementation, verification and management in designing stunting early detection systems. The stages in the waterfall method are explained in Fig 1.

The waterfall method chosen uses a series of logical phases from one stage to another with a basic assumption that the software to be designed, built and tested must be defined upfront (Larson and Gray, 2011). It includes successive phases which must be completed one after the other. It begins with an analysis phase which analyzes user needs. This model is considered to offer a well-defined set of criteria and requirements even before starting the project design and implementation phases. It provides a basic plan of the project before starting the project phases orderly (Dima and Maassen, 2018). With such advantages, it can save time in the development process (Kannan *et al*, 2014).

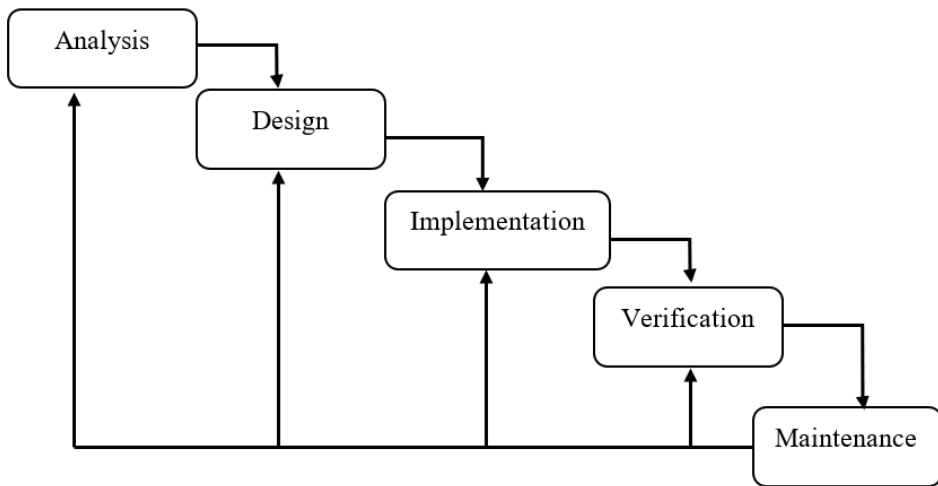


Fig 1 - The waterfall method

The waterfall method comprises several steps. The first is analysis stage which is a complete description of software attributes. This phase requires an analyst who are able to define functional and non-functional aspects of the software, such as objectives, scope, perspective, functionality, software attributes, user characteristics, database requirements, constraints, limitations, design and operation. Analysis phase possesses some properties such as reliability, scalability, testability, performance, and quality standards. The second phase is design phase which includes the planning and problem-solving processes. Software developers design the usage case diagram, flow chart system, and further aspects. Next, the third phase is implementation phase where a solid program execution phase took place. This phase involves the act of converting from the process phase to the production phase.

Afterwards, the fourth phase is testing phase, known as verification and validation, which include checking process where the software expectations meet the original performance and specifications, as well as accomplish its intended purpose. Then, the verification phase was performed as a software evaluation process to determine whether the product at a given phase meets the initial conditions. Validation, on the other hand, refers

to evaluating software during and at the end of the development process to find whether it meets the specified requirements. In this phase, bugs and system glitches were located and fixed. Lastly, this study performed the maintenance phase modifying the software solution after delivery and deployment to improve output, correct errors, and improve performance and quality. It may also include the software adaptation to its environment, accommodation of new user needs, and increase in its reliability (Bassil, 2012).

Selection and description of participants

Participants in this study were health cadres who worked in health integrated service posts, had an Android smartphone and were aged 20-40 years. Coordination with the cadres was done on a WhatsApp group, and the informed consent forms were sent to the group as well. This research has received an ethical approval certificate from the ethics committee of the State Polytechnic of Jember number 1180/PL17.4/PG/2022.

Research procedures

One way to detect stunting is done through physical/anthropometric detection. Based on toddler age, physical detection could be carried out from toddler height and weight. The height and weight were standard data that were manually collected in separate data sheets. To facilitate better data collection, numerical data at the time of measurement were displayed on a liquid crystal display (LCD) and smartphones. The Arduino Nano microcontroller which has Input/Output I/O pins were used to measure height, age and weight values sent by the circuit and accompanied by serial communication using Bluetooth. Thus, the data could be displayed on a smartphone in real time (Fig 2).

The design system used an automatic system with Arduino nano

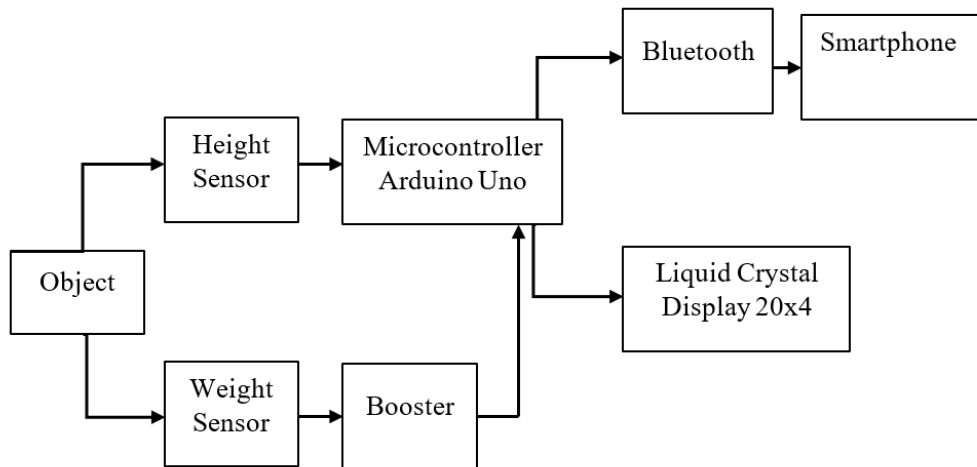


Fig 2 - The flow of the system

microcontroller on Arduino software which is easy to use. The installation of the system went directly into the circuit (Fig 3). The system adopted the results of previous studies applied to automatic height selector gates on Arduino-based playgrounds (Ramadan and Mujahidin, 2015). The tool in this study was the Android operating system to monitor height, weight and age of infants and toddlers in PHC. The system using a body length sensor used by previous researchers was adopted (Ardianto *et al*, 2022). The application of this system will help PHC conduct the measurement automatically. With this system, the results of the measurement would appear on the LCD and android smartphone in real time (Fig 3).

User satisfaction was measured using a questionnaire that was distributed online using Google Forms. The participants of the study were 30 respondents (cadres). Alpha testing was carried out using the Black Box method with Likert scale modified from Nemoto and Beglar, (2014). Their research consisted of 6-point questionnaire which items required approval or disagreement. The standard assessment used was Likert scale with five parameter values: 1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4= Agree;

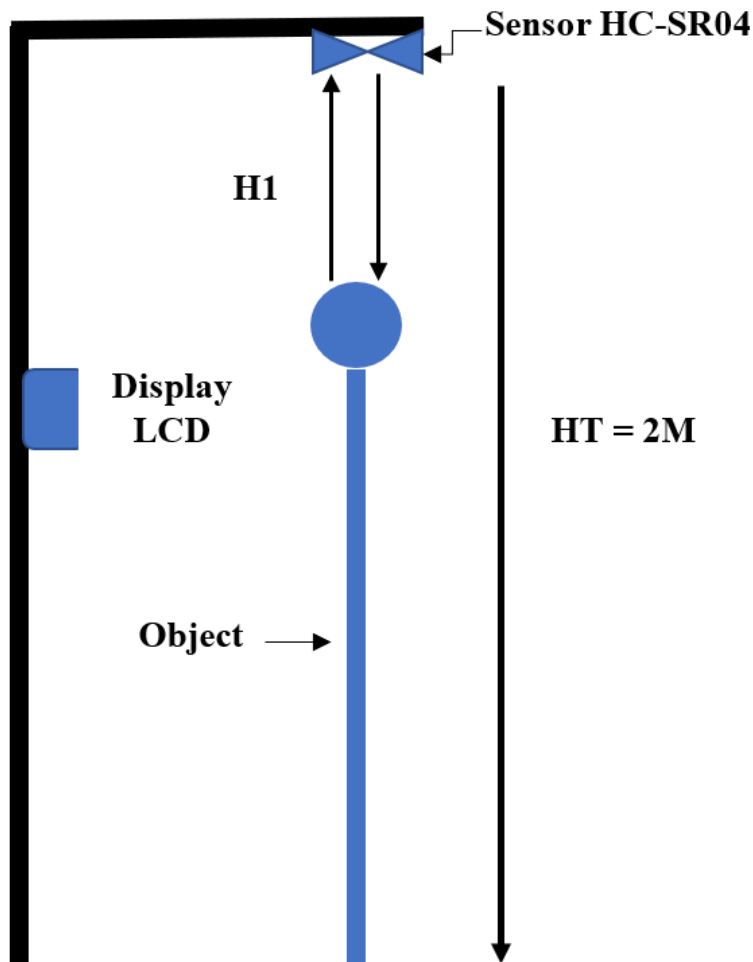


Fig 3 - Illustration of height measurement

Note: Ultrasonic sensor HC-SR04 used was the product of Guangzhou Eagle Electronic Company, Guangzhou, PRChina.

HT: height that has been set; H2: height measured; LCD: liquid crystal display; m: meter

5 = Strongly agree. This study used five-point Likert scale by the following formula: $P = \frac{f}{N} \times 100\%$; where P = percentage, f = frequency of questionnaire answers, N = number of ideal scores, 100% = fixed number.

The test indicators on the questionnaire included a user interface with three questions, the questions which were:

1. Are the menus or menu application features easy to use?
2. Is the application easy to operate?
3. Is the appearance of the menu in the application easy to recognize?

and the functionality of the application with five questions which were:

1. Is this app suitable for your needs?
2. Is the application useful for users?
3. Is the chat feature on the app can be used well?
4. Is the tracking toddler history on the app working fine?
5. Does the application provide easy-to-understand information?

Before the respondents filled out the questionnaire provided by the researchers, the initial step was by conducting a system demo and user trial. User satisfaction was measured based on the percentage of questionnaire results, scaled from 0-100% with the following categories: very good = 61-100%; good = 46-60%; enough = 31- 45%; not good = 16-30%; very poor = 0-15%. At the end of the evaluation, we involved two expert professions. First, health workers acted as evaluators of maternal and child health programs at PHC, and second were nutritionists at the district health office. They were involved in the operating and interaction processes with users during the tool testing process.

RESULTS

The results of this study showed outputs from analysis, design, implementation, verification and maintenance, in the form of Usage Case Diagrams, Flow Chart Systems, and splashscreens with menus for logins, application trials and user satisfaction tests, as illustrated in Figs 4-7 and Tables 1 and 2.

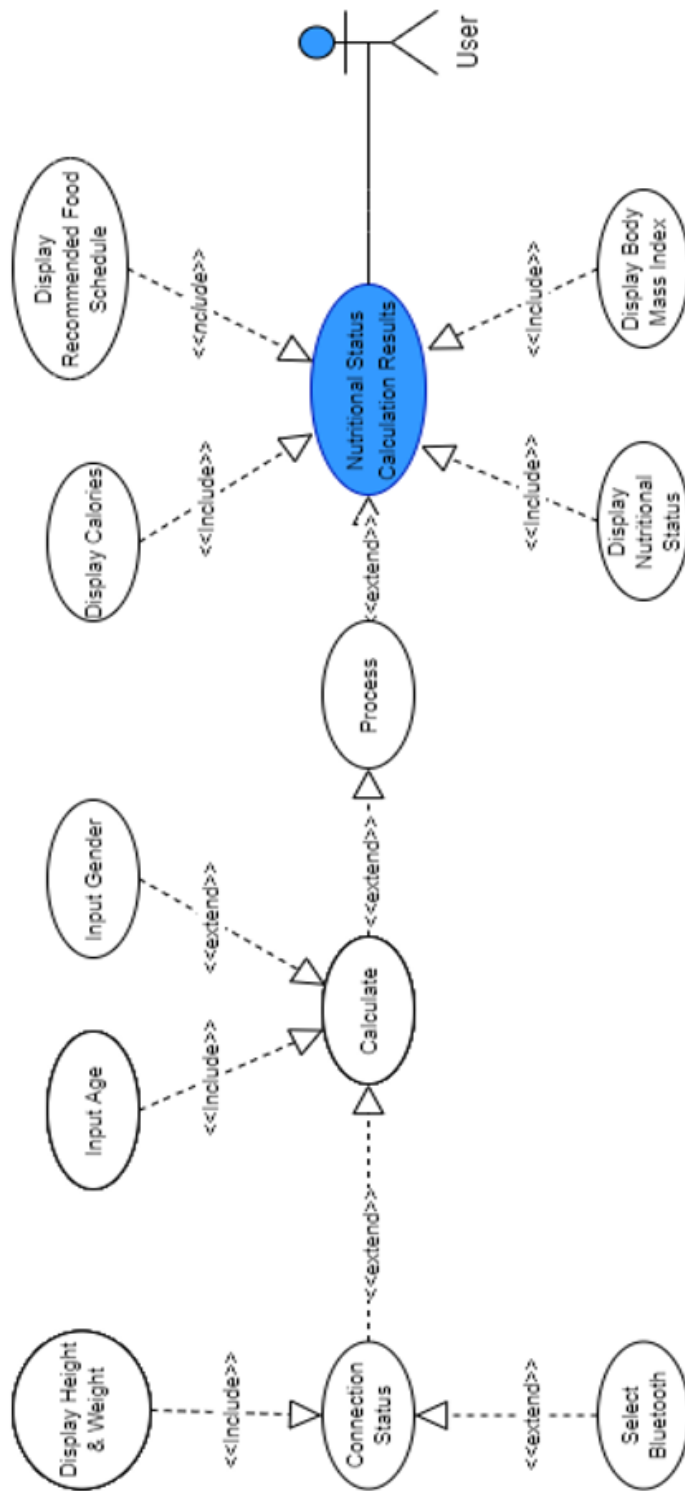


Fig 4 - Usage case diagram for stunting toddlers

Table 1
Application testing of questionnaire results

Question	Frequency of the responses, <i>n</i> (%)			
	Strongly disagreed	Disagreed	Neutral	Agreed
Menu application features are easy to use	0 (0.0)	0 (0.0)	0 (0.0)	16 (53.3)
Application is easy to operate	0 (0.0)	0 (0.0)	1 (3.3)	17 (56.7)
Menu display is easy to recognize	0 (0.0)	0 (0.0)	1 (3.3)	15 (50)
Application is suitable as needed	0 (0.0)	0 (0.0)	2 (6.6)	17 (56.7)
Application is useful for user	0 (0.0)	0 (0.0)	1 (3.3)	13 (43.3)
Chat feature can be used well	0 (0.0)	0 (0.0)	3 (10)	13 (43.3)
Tracking history works fine	0 (0.0)	0 (0.0)	2 (6.6)	18 (60)
Information is easy to understand	0 (0.0)	0 (0.0)	0 (0.0)	15 (50)
				14 (46.7)
				12 (40)
				14 (46.7)
				11 (36.7)
				16 (53.4)
				14 (46.7)
				10 (33.4)
				15 (50)

Table 2
Application testing of user satisfaction

Question number	Rating scale x Occurrence frequency data					Score	User satisfaction rating scale (%)
	1	2	3	4	5		
1	0	0	0	64	70	134	89
2	0	0	3	68	60	131	87
3	0	0	3	60	70	133	89
4	0	0	6	68	55	129	86
5	0	0	3	52	80	135	90
6	0	0	9	52	70	131	87
7	0	0	6	72	50	128	85
8	0	0	0	60	75	135	90

The system design flow started from the calibration process for the load cell and height sensors, followed by reading of load cell sensors and height sensors. If the sensor managed to read, then the weight and height sensor was detected. However, if the sensor was not able to read, then the reading of load cell sensor and height was repeated again. The next step was calculating the z-score which was processed through the Arduino system. The results of the calculation were displayed on the LCD screen and sent using Bluetooth assistance (Fig 5).

Fig 5 displays the system flowchart when the device was turned on, while the height and weight sensor detects a toddler being weighted hence Arduino's bluetooth module would automatically activate. Then the user can put in data of age and gender to determine nutrition status for toddlers. Data appeared on Android phone were about the nutritional status, type and schedule of food.

The splashscreen page of this application (Fig 6), was used for cadres to monitor their performance in detecting stunted toddlers. When the measuring instrument was on, the application led the user to activate the

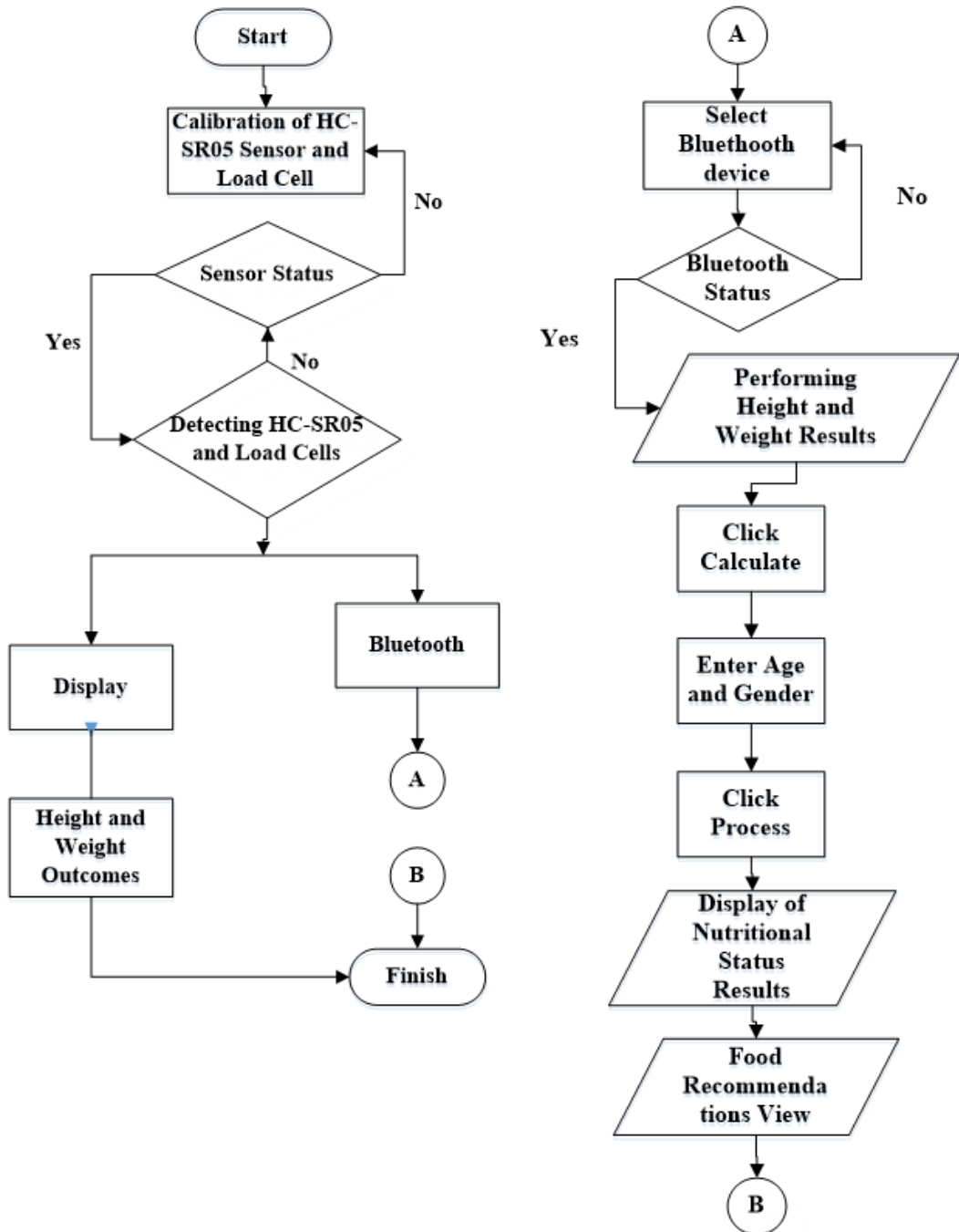


Fig 5 - Flow chart system based on Arduino and Android operating system

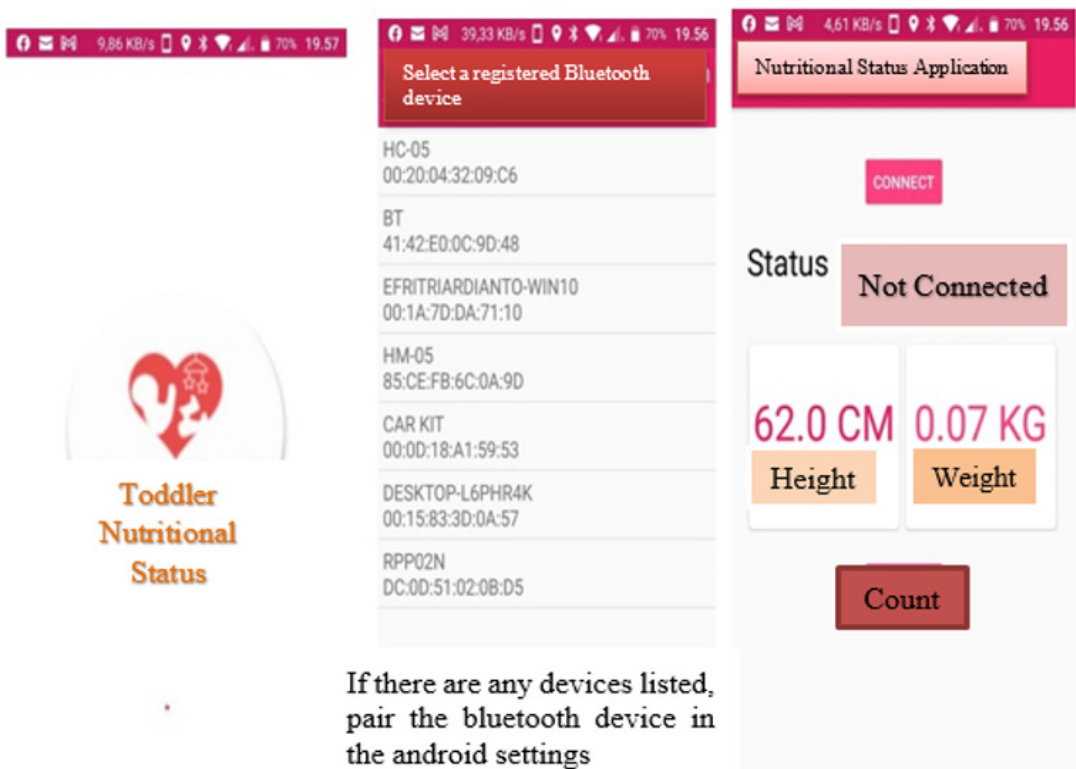


Fig 6 - Splashscreen page for user

CM: centi meter; KG: kilogram

Bluetooth device. Furthermore, it was connected to the menu to calculate the toddler nutritional status. After the Bluetooth connection was established, the user would be asked to input the age and the gender. Afterwards, the application showed nutritional status and recommendations for types of food and eating schedules. The menu page user interface is illustrated in Fig 7.

Application evaluation was carried out with two sources of information: users and a team of experts. All feedbacks for improvement purpose were considered and implemented on the prototype design. System testing was carried out using Alpha testing and Beta testing as illustrated in Tables 1 and 2. Table 1 is the result of 30 respondents who filled out

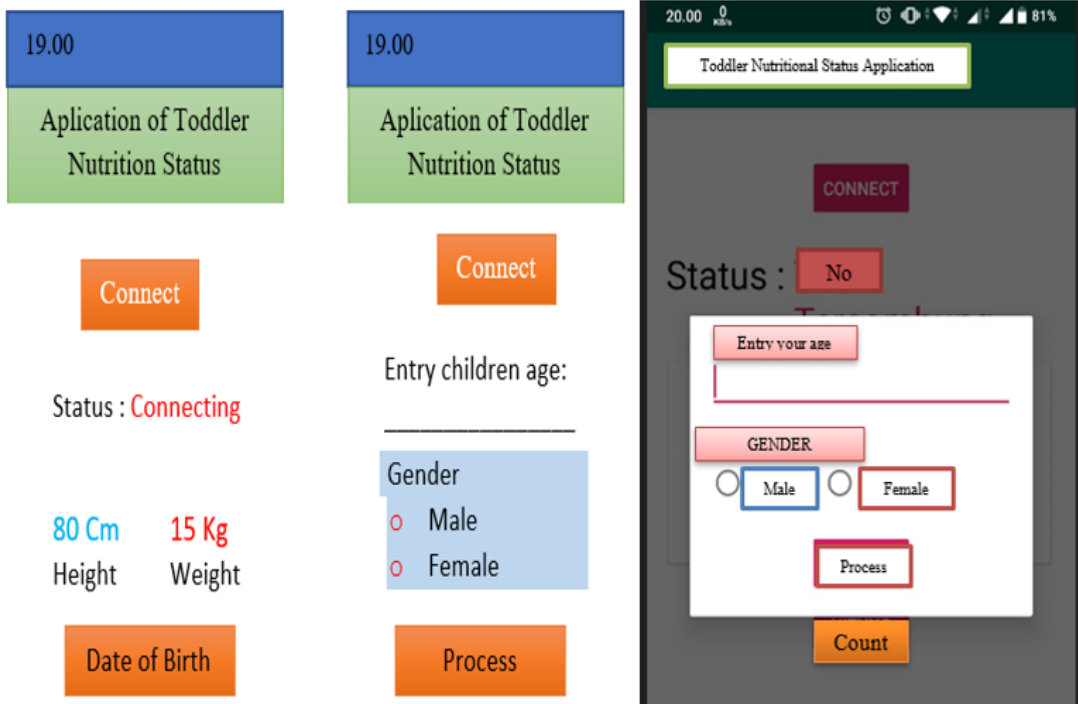


Fig 7 - Login and register menu for user

Cm: centimeter; Kg: kilogram

a questionnaire in a five-point Likert scale, which was used to calculate the percentage of each question.

Questionnaire application testing mostly stated that 43-60% of the users agreed, neutral of 3.3-10%, and not agreed of 0%.

According to the measurement of user satisfaction based on Table 2, 89% of users stated that the application features were easy to use; 87% said the application was easy to operate; 89% said the appearance of the application was easy to recognize; 86% said the application was in accordance with needs; 90% of respondents said this application was useful for users; 87% of users stated that the chat feature worked very well; 85% of users stated that tracking toddler history on the application was running very well.

Lastly, 90% users said that the application provided easy and understandable information. Measurement or rating provide certain and constant, easy and fast results of internal attributes such as attitudes, opinion levels, satisfaction, motivation, self-discipline, and self-efficacy. Both expert evaluators stated that the detection and application measurement tools were very easy to use and understand by users.

DISCUSSION

The system had some components: (1) baby objects as data input; (2) height sensor, weight sensor and amplifier; (3) Arduino as the third sensor data processor will sent the data to Android smartphone; (4) Bluetooth as serial communication; (5) LCD for displaying measurement results; (6) The Android smartphone for displaying data sent via Bluetooth using the Mitapp inventor software developed from the previous research (Ardianto *et al*, 2022).

Arduino microcontroller was tested using a simple program and circuit that were made to ensure all pins on the microcontroller were still functioning. The simplest test program was used to turn on the light emitting diode (LED). The connection between the LEDs was on pin 13 of the Arduino microcontrollers. This testing aimed to find out whether the microcontroller was still working properly or damaged. Furthermore, the testing of Arduino nano microcontroller used 5-volt LED. The general description of the application addressed the data input process (measurement). Arduino proceeded the data and sent them to a smartphone via Bluetooth. This concept refers to the results of previous research which used Bluetooth as a wireless network to send data (Iskandar *et al*, 2019; Chanda *et al*, 2016).

Infants and toddlers become the object of data input which gives information about weight, height, age, and gender. Afterward, the height and weight sensors read the data and displayed them in numbers on the LCD and Android smartphones since the Arduino nano microcontroller had I/O pins to read the height, age and weight values sent by the circuit and accompanied by serial communication between Bluetooth.

This study produced an anthropometric detection system of nutritional status in infants and children under two years old using several z-scores, length/height for age, weight to height, weight for age and body mass index for age parameters (MOH RI, 2020b; WHO, 2008; WHO/UNICEF, 2009).

The recommended feeding schedule was compiled based on the toddler feeding recommendations by the Indonesian Ministry of Health, the guide to the contents of plate for toddlers, guide to balanced nutrition, and recommendations by the National Health and Medical Research Council (MOH RI, 2020a; National Health and Medical Research Council, 2012; Indonesian Pediatric Society, 2019).

Based on toddler feeding schedules and textures recommended by the WHO, giving small amounts of food should start at six months of age, and the quantity of feeding increases as the child gets older, while mothers maintain frequent breastfeeding until 2 years old (Dewey, 2003). For example, the total energy needed for children aged 6-8 months with “average” breast milk intake in developing countries was approximately 200 kcal per day from complementary food, and it increased as the child get older. There are two kinds of complementary foods: specially prepared foods and family foods that are modified to make them easy to eat enough nutrients. Increasing food consistency and variety has to be adapted to the infant’s requirements and abilities. Adding a variety of vegetables to the child’s diet greatly contributes to meeting micronutrient needs. If not, infants suffer from micronutrient deficiency, especially after the exclusive breastfeeding period was over. Besides, iron deficiency or better known as iron deficiency anemia (IDA) often occurs due to a lack of iron intake, vitamin B12 and folic acid. The high IDA incidence was noted among infants aged 9-12 months. The recommended iron dietary portion for children from 1 through 3 years of age is 7 mg/day. At six months of age, the baby start eating pureed, mashed and semi-solid foods; by 8 months, most babies also eat “finger foods”. At 12 months, most children eat the same types of foods as consumed their family, but they need to be careful with legumes and whole grains, popcorn, long greens, fish bones, cuts of meat and cheese, hard candy, meatballs, or other foods

that may cause choking (Dewey, 2003; Baker *et al*, 2010; Wang, 2016; Joo *et al*, 2016; WHO, 2000).

Application evaluation was conducted using alpha and beta testing. Alpha testing was carried out using the Black Box method in Likert scale. Beta testing was carried out to check and certify a software and describe the external testing process where software was distributed to other users who had the potential to use the software daily. The object of beta testing in this study was cadres. The rating scale in beta testing was developed earlier by Renis Likert to find out the extent to which a person agrees or disagrees. Then, the rating scale is developed in accordance with the objectives and objects of research (Aiken, 2001; Wright and Masters, 1982). There are many types of Likert scale, and the popular types were the five-point Likert scale and the six-point Likert scale (Chomeya, 2010). The range of the user satisfaction score in this study was from 87% to 90% which was in good category and acceptable. There was no standard measure of user satisfaction about the application because exogenous variables were not well controlled. Therefore, there is a need for a comprehensive and valid set to measure user satisfaction, such as a standardized instrument that measures not only the general reaction of users to each factor, but also a series of questions to determine the respondents' reasons for responding that way (Zviran and Erlich, 2003).

Related to the previous research on user satisfaction about Halodoc application in Indonesia, there were several factors associated with the user satisfaction. For example, ease of use is one of them related to button design, colors, and most information. The reliability of information, simplification of usage procedures, affordability, and availability of personalized healthcare services are specifically related to user satisfaction. Besides, several profile features such as education affect the level of acceptance which turns out to be satisfaction (Azzahrah *et al*, 2020).

Similar research on user application experience has been conducted in Indonesia. They analyzed 30 stunting detection applications on the Playstore.

However, none of them addressed a nutrition calculator application called Balungan Sehat released by the Indonesian Ministry of Health. But still none of the research addresses the integration of general health applications and anthropometric tools for nutritional status. Considering that the measurement system, recording and reporting of nutritional status of toddler in Indonesia are still fragmentary, the tools will greatly benefit the community, especially cadres and health workers. Not only is it designed to improve all technology literacy skills, but also to provide complete health service facilities. Besides, it is able to provide convenience in diagnosing the nutritional status of toddlers and recommendations for early intervention to individuals with nutritional problems. Some of the recommendations include giving information on permissible food and snacks for toddlers, including time, amount, food texture, and food ingredients. These tools are also equipped with an immunization feature that allows the user to fill in their immunization schedules directly. In the near future, these tools need to be developed to provide infographics related to nutrition.

ACKNOWLEDGMENTS

The authors would like to thank the respondent who participated in this research. Special thanks also to information technology laboratory officer at the Politeknik Negeri Jember.

CONFLICT OF INTEREST DISCLOSURE

The authors report no conflict of interest in this research.

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