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Advanced Infant Scale: Function Enhancement by Integrating a Monitoring Application for Growth and Development Assessment

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Abstract
StuVent is an application designed to provide information on the health status of infants aged 0-24 months and to detect early stunting. This application displays the classification results of the infant's health status, differentiated by colour, making it easier for users to understand the infant's health status. StuVent is aimed at Posyandu's staff and the general public to help them detect early stunting. The main advantage of this application is its ability to work offline using Bluetooth Low Energy (BLE) connectivity. Users can connect their smartphones to the scales via Bluetooth, allowing the application to be used without an internet connection. This feature is particularly beneficial for users in 3T areas (frontier, outermost and remote regions) where internet access is often limited. StuVent is therefore expected to be an effective tool for monitoring child growth and preventing stunting in various regions.
Keywords: *StuVent, early detection of stunting, offline application, Bluetooth Low Energy (BLE)*

Abstrak
StuVent adalah sebuah aplikasi yang dirancang untuk memberikan informasi mengenai status kesehatan bayi usia 0-24 bulan serta mendeteksi dini *stunting*. Aplikasi ini menampilkan hasil klasifikasi status kesehatan bayi yang dibedakan berdasarkan warna, sehingga memudahkan pengguna dalam memahami kondisi kesehatan bayi. StuVent ditujukan kepada kader posyandu dan masyarakat umum untuk membantu mereka dalam mendeteksi *stunting* sedini mungkin. Keunggulan utama aplikasi ini adalah kemampuannya bekerja secara *offline* menggunakan koneksi *Bluetooth Low Energy* (BLE). Pengguna dapat mengkoneksikan *smartphone* mereka dengan timbangan melalui *Bluetooth*, sehingga aplikasi ini dapat digunakan tanpa memerlukan akses internet. Hal ini sangat bermanfaat khususnya bagi pengguna di daerah 3T (Terdepan, Terluar, dan Tertinggal) yang seringkali memiliki keterbatasan akses internet. Dengan demikian, StuVent diharapkan dapat menjadi alat yang efektif dalam pemantauan tumbuh kembang bayi dan pencegahan *stunting* di berbagai wilayah.
Kata Kunci: *StuVent, deteksi dini stunting, aplikasi offline, Bluetooth Low Energy (BLE)*

1. Introduction

Stunting is a condition where a child's growth is impaired due to chronic malnutrition, repeated infections, or other environmental factors. According to WHO, an individual is considered stunted if their height-for-age z-score is less than -2 standard deviations (SD) from the international growth reference median [1]. In Indonesia, the prevalence of stunting remains a significant public health issue. Data from the 2022 Basic Health Research (Riskesdas) indicates that approximately 21.6% of children under five in Indonesia suffer from stunting [2]. This figure means that one in five children has delayed growth, which can negatively impact their physical and cognitive development in the future. The causes of stunting in Indonesia are complex and multifaceted. The main factors include inadequate nutritional intake from pregnancy, poor sanitation, and limited access to quality healthcare services [3]. Additionally, contributing factors such as socioeconomic conditions, including poverty and maternal education, also play a role in exacerbating this issue [4]. Low community awareness in preventing and detecting stunting early is a major challenge. The public often lacks knowledge and awareness about the importance of nutrition and child health, leading to delays in addressing stunting issues [5].

Furthermore, the role of healthcare workers, especially Posyandu’s workers, is crucial in tackling stunting. Posyandu’s workers serve not only as nutrition educators but also as health monitors and supporters [6]. They play a role in providing education to the community and in the routine monitoring of children's health. However, the current data transmission and health monitoring processes from Posyandu are time-consuming and inefficient, leading to delays in stunting prevention.

To address this issue, the development of information technology is being explored as an effective solution. The StuVent application is introduced as an innovation to assist in early detection of stunting. This application operates offline using Bluetooth Low Energy (BLE) technology to connect smartphones with weighing scales. By leveraging this technology, StuVent facilitates the real-time monitoring of children's health by Posyandu's workers and the community. StuVent can provide real-time health status of children and aid in the early detection of stunting, thus enabling quicker and more accurate interventions. It is hoped that using this application will increase awareness and preventive actions against stunting in the community. Overall, the StuVent application offers a significant solution to the stunting problem by providing a practical and efficient tool for both the community and healthcare workers to monitor and detect stunting early, ultimately contributing to the reduction of stunting prevalence in Indonesia.

2. Methodology

A. Bluetooth Low Energy Implementation in StuVent

The application connects with a scale by utilizing Bluetooth Low Energy (BLE) technology in its operation. BLE is preferred due to its low energy consumption. Thus, making it ideal for the scale that does not require a large power supply and has a limited Bluetooth wireless range. BLE is a type of Bluetooth that uses low energy, making it widely used in microcontrollers and IoT systems that require long-term usage [7].

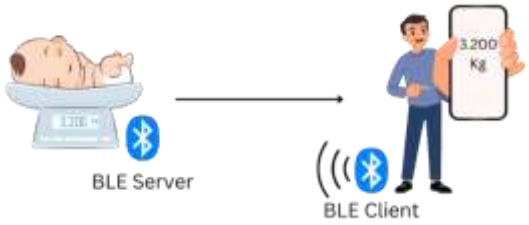


Fig. 1: BLE server to BLE client

According to the **Fig. 1**, the scale acts as a server that implements structured attribute completeness in the form of services and characteristics. In other words, the server stores useful data that can be accessed remotely by a client [8]. A BLE server can be referred to as a GATT (Generic Attribute Profile) server. A GATT server contains one or more GATT services. Regarding general BLE communication, the scale with a BLE server has a Generic Access Profile (GAP) responsible for setting the device address according to the client's privacy constraints. The address set by GAP is similar to a MAC address, consisting of 6 bytes in the form of 12 hexadecimal digit. An example is illustrated in **Fig. 2** bellow.

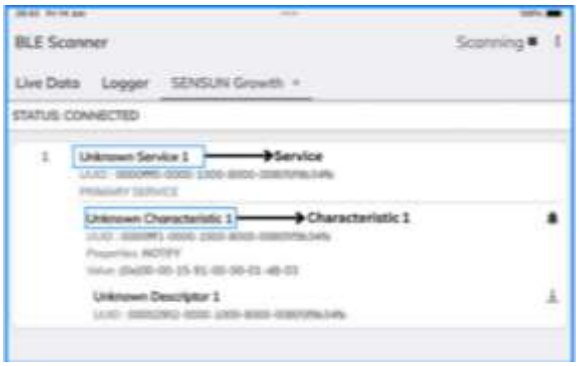


Fig. 2: BLE scanner

Characteristics in BLE communication consist of at least two attributes: a characteristic declaration attribute and a characteristic value attribute [9]. Characteristic declaration attribute includes the UUID to uniquely identify the characteristic and information about the permissions [10]. Characteristic value contains the current weight reading. How Measurement Values from the Scale are Received by the Application via BLE? The measurement data is received by the device in the form of bytes. Therefore, it requires conversion, starting with separating the hexadecimal data into individual bytes (byte1, byte2, byte3, byte4), which represent weight and height information. These bytes are then converted into hexadecimal values for weight and height. Finally, the hexadecimal values are converted into decimal

values (decimal Value and decimal Value High) using radix 16 (hexadecimal base) and then transformed into string data.

B. Child Nutritional Status Index Based On Z-Score

Nutrition is an essential substance required by living organisms for optimal growth and development. A child's nutritional status reflects their health condition, influenced by the balance between nutritional needs and intake received [11]. Nutritional status can change with variations in food intake and individual needs [12]. A child's nutritional needs vary depending on factors such as weight, height, and age. Nutritional assessment and monitoring by healthcare professionals, such as doctors, are crucial to ensuring a child's health. This assessment follows anthropometric standards set by the WHO [13]. For infants aged 0-24 months, measurement indicators use z-scores with units of standard deviation (SD) listed in the WHO nutritional index tables. These standards are used as references by the Ministry of Health in assessing a child's nutritional status [14].

Nutritional indices based on z-scores include:

- Weight-for-Age (BW/A): Measures the child's weight relative to their age.
- Length/Height-for-Age (BH/A): Measures the child's length or height relative to their age.
- Weight-for-Length/Height (BW/BH): Measures the child's weight relative to their length or height.
- Body Mass Index-for-Age (BMI/A): Measures the child's body mass index relative to their age [10].

Data from various studies indicate that regular monitoring using these indicators is crucial for the early detection of nutritional problems and appropriate interventions [15]. The Ministry of Health uses these standards to track and improve the nutritional status of children throughout Indonesia, with the aim of reducing the prevalence of malnutrition.

```
HasilChildOutputScore hitungPbUmur(RumusInputModel rumusInputModel) {
    if (rumusInputModel.jenisKelamin == 'L') {
      HasilChildOutputScore data = HasilChildOutputScore();
      var pengukuran = rumusInputModel.panjangBadan;
      var median = rumusStunting.rumusPbUPria[rumusInputModel.umur]![3];
      var nilaiRujukan = pengukuran! < median
          ? median - rumusStunting.rumusPbUPria[rumusInputModel.umur]![2]
          : rumusStunting.rumusPbUPria[rumusInputModel.umur]![4] - median;
      var zIndeks = (pengukuran - median) / nilaiRujukan;
      zIndeks = double.parse(zIndeks.toStringAsFixed(1));
      data.zIndeks = zIndeks;
      data.batasAtas = rumusStunting.rumusPbUPria[rumusInputModel.umur]![6];
      data.batasBawah = rumusStunting.rumusPbUPria[rumusInputModel.umur]![1];
      return data;
    }
```

Fig. 3: Source code based on z-score formula

Based on the source code snippet above, the application processes measurement data by applying the z-score formula as follows:

$$\frac{(\text{Measurement Value} - \text{Median Reference Value})}{\text{Reference Standard Deviation Value}}$$

To obtain each value, it is necessary to initialize variables that call the respective values. The measurement values are obtained from the measured weight (BW) and length/height (BH) according to gender. The median reference value and the reference standard deviation value are obtained from the Ministry of Health's reference table, which has been converted into a 'map list' according to age (in months) in the program.

C. Application Features and How It Works

The main function of the StuVent application is to perform measurements and display information on the nutritional index and the growth status of children. Therefore, it includes several features to assist users, including:

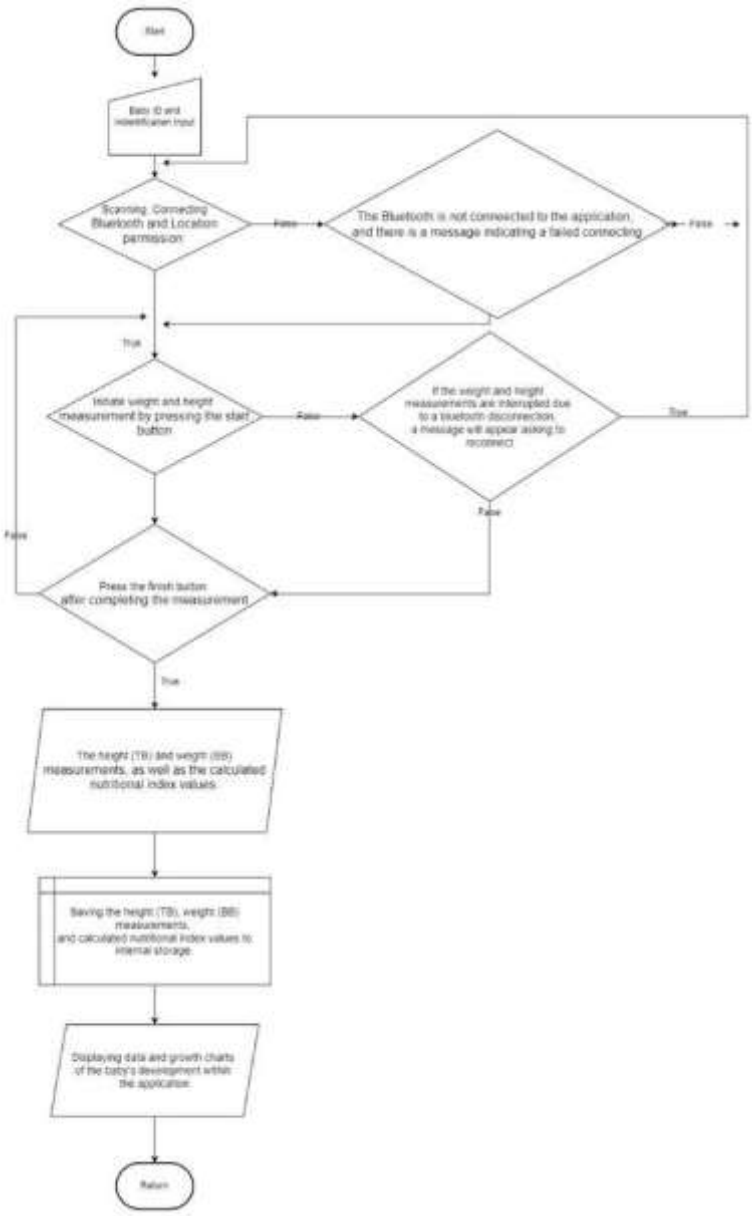


Fig. 4: Flowchart application

a. Posyandu Data Input

This feature allows users to enter general information about the Posyandu conducting the measurements and data collection. If the application has been used and the user wishes to switch devices or recover data, there is a feature available to enter a backup code to restore the data.

Fig. 5: Posyandu Data Input

b. Add Child Data

This feature allows users to add a child's identification details, including gender, NIK (National Identification Number), full name, date of birth, and mother's name.

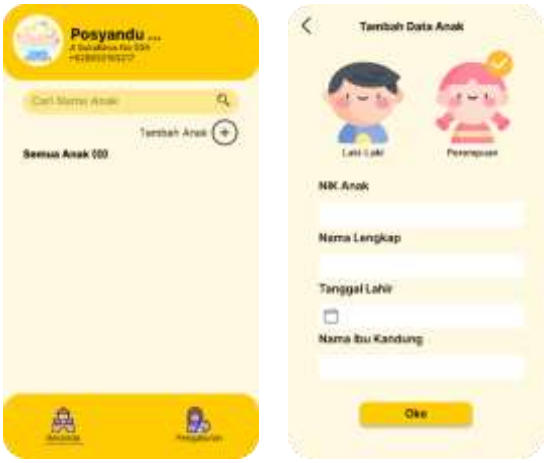


Fig. 6: Add child data

c. Bluetooth Scanning

This feature enables Bluetooth on the device and scans for available Bluetooth connections. Once Bluetooth is connected, measurements can be conducted. Bluetooth connectivity plays a crucial role; therefore, if the application and Bluetooth connection are lost or not connected, the application will attempt to reconnect up to five times.

Fig. 7: Bluetooth scanning

d. Measurement Feature (Real-time)

This feature allows users to measure a child's weight and height by pressing the 'mulai ukur' button. The values will then appear and be clearly visible to the user. Users can also manually enter head circumference and arm measurements. Bluetooth plays a crucial role here by receiving measurement values from the scale, ensuring they are saved in the application and processed for results.

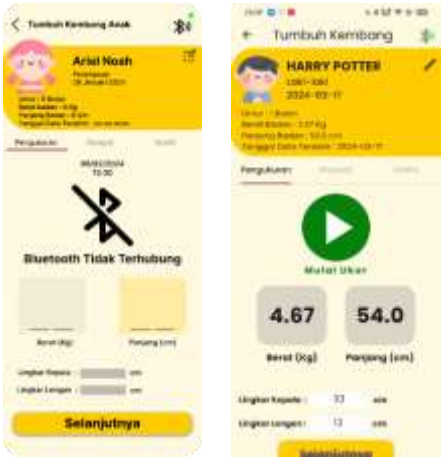


Fig. 8: Measurement feature

e. Nutritional Status Index Results Feature

Fig. 9: Nutritional status index results feature

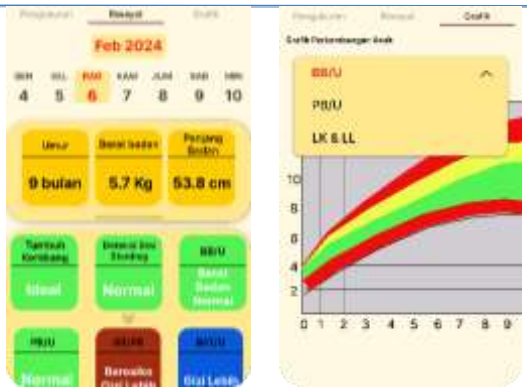
This feature can differentiate the child's nutritional status index based on color and z-score calculations. The color-coded information aims to help users distinguish and remember each category more effectively, as shown in **Fig. 9**. The categories of the child's nutritional status index are distinguished by color, which are:

1. Red: Severely underweight.
2. Yellow: Underweight.
3. Green: Normal.
4. Blue: Tall, overnutrition, and obesity.
5. Brown: At risk of overnutrition.

Additionally, this feature provides other information that can summarize measurement data with growth status displayed as 'Ideal' or 'Growth Failure' and early stunting detection status displayed as 'Normal' or 'Detected Stunting'.

f. History and Graph Features

This feature presents information in a visual format, available in the history and graph sections. The provided graphs are designed to match the visuals of the KMS (Kartu Menuju Sehat) charts, ensuring that Posyandu's worker and parents find them familiar and easy to understand.



(a) (b)

Fig. 10: History and graph features

g. Data Backup Feature

The data backup feature creates a copy of the data to be uploaded to Firebase, thereby reducing excessive local storage usage. Users are provided with an access code to restore the backed-up data. This feature is utilized when the user's device has internet connectivity.

Fig. 11: Data backup feature

h. Data Restore Feature

The data restore feature retrieves data from Firebase and saves it back into the internal storage. On this page, users are prompted to enter the access code that was copied from the data backup page. Similar to the data backup feature, data restore also requires internet access.

Fig. 12: Data restore feature

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3. Experimental and Result

The application must connect with the scale to display information about the child's health status. The measurement results displayed on the scale's LCD and the application must be the same. The measurement index in the application are divided into 4 types, which are BW/A, BH/A, BW/BH, and BMI/A, as shown in the following figures:

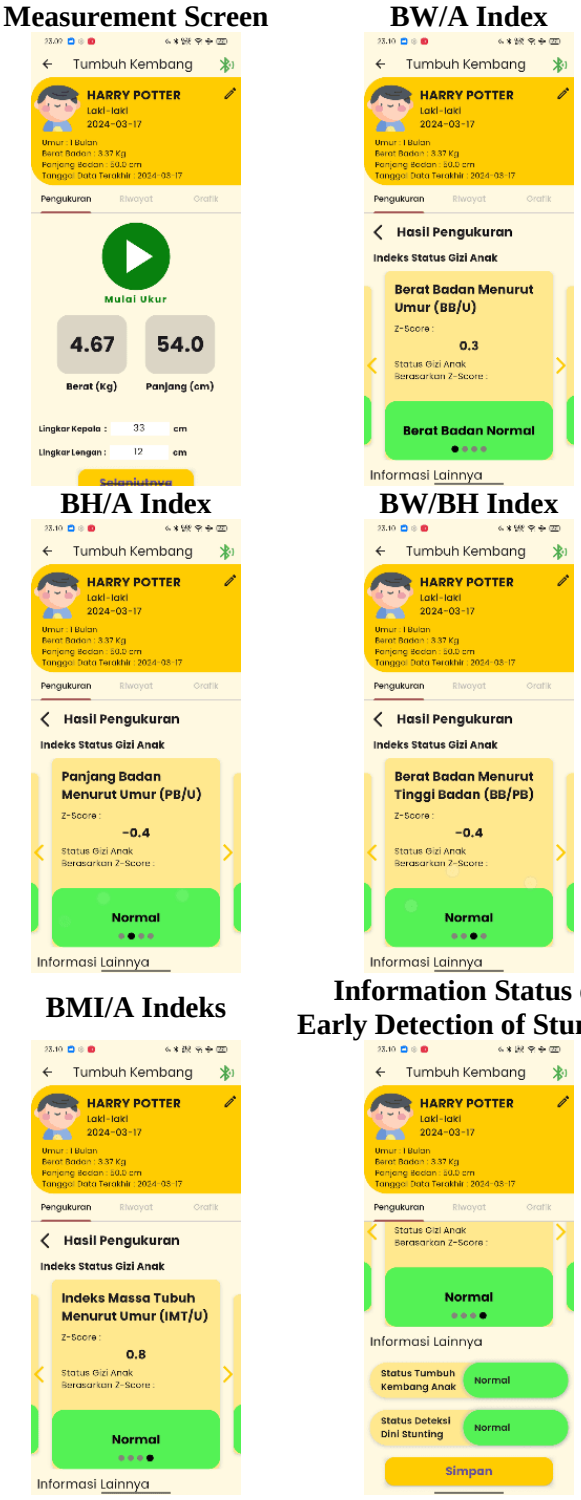

Fig. 13: Child health status

Additionally, the status of other measurement results can be seen in the table below:

1) Various display classes for body weight index

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In **Table 1**, the child's health status based on weight-for-age (BW/A) can be differentiated into 4 colors: Green for normal, yellow for underweight, red for severely underweight, and brown for at risk of overweight.

Table 1: Various display classes for body weight index

Various Display Classes for Body Weight Index	
	
	

2) Various display classes for body height index

In the **Table 2**, the categorization of children's height status is divided into 4 categories: "Normal" (green), "Short" (yellow), "Very Short" (red), “Tall” (blue).

Table 2: Various display classes for body height index

Various Display Classes for Body Height Index	
	
	

3) Various Display Classes for Body Weight/Body Height Index

In the **Table 3**, the categorization of nutritional status based on height is divided into 6 categories: "Normal" which is colored green, "Malnutrition" which is colored yellow, "Severe Malnutrition" which is colored red, “Risk of Overnutrition” which is colored brown, and blue for “Overnutrition” and “Obesity”.

Table 3: Various display classes for body weight/body height index

Various Display Classes for BW/BH Index		
		
		

4) Various Display Classes for BMI Index

In the **Table 4**, the categorization of weight status according to BMI is divided into 6 categories: "Normal" (green), “Malnutrition” (yellow), “Severe malnutrition” (red), "At Risk of Overnutrition" (brown), “Overnutrition” and "Obesity" (blue).

Table 4: Various display classes for BMI index

Various Display Classes for BMI Index		
		
		

In addition to the measurement feature, there are also history and graph features that can be accessed at any time. The history feature displays the measurement results from the previous month. Meanwhile, the graph feature is provided to monitor the child's growth and development. There are 3 types of graphs available: weight-for-age (BW/U) index, height-for-age (BH/U) index, and head circumference and arm circumference graph. The graph's format in this feature adapts from the growth chart used in KMS, with color-coded labels corresponding to the child's nutritional status index calculation results. The plotted points are displayed in black and white, indicating the measurement values. Users can observe the fluctuations in the child's growth graph, and whether the points fall within the normal range or not. It shows on **Fig. 14.**

Fig. 14: Graph features

4. Conclusion

Based on the testing results from **Tables 1-4**, information regarding the baby's health status can be distinguished based on color indicators. The baby's health status refers to the z-score table integrated into the application's logic program. In the conducted experiment, it was proven that the StuVent application successfully provided information about children's health status and early detection of stunting. StuVent presents data in the form of text and striking colors, making it easier for users to remember and distinguish each category. This is expected to assist the general public in promptly referring children detected with stunting to relevant professionals for appropriate intervention.

5. Abbreviations

3T	Terdepan, Terluar, Tertinggal
BH	Body Height
BLE	Bluetooth Low Energi
BMI	Body Mass Index
BW	Body Weight
GAP	Generic Access Profile
GATT	Generic Attribute Profile
KMS	Kartu Menuju Sehat
Riskesdas	Basic Health Research
SD	Standard Deviation
WHO	World Health Organization

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