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Implementation of Decision Support System Techniques in Evaluating IoT-Based Anthropometric Devices for Stunting Prevention in Toddlers

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Abstract. Stunting remains a significant national health issue in Indonesia, prompting the government to focus on its prevention through regular monitoring of child growth. This study aimed to determine the preferred IoT-based anthropometric measuring device for toddlers using Decision Support System (DSS) methods, specifically Analytic Hierarchy Process (AHP), Weighted Product (WP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Two products, Product A and Product B, were evaluated based on criteria including accuracy, ease of use, durability, connectivity, and cost. The AHP method was used to determine the criteria weights, followed by the application of WP and TOPSIS to rank the products. The results indicated that Product A was consistently preferred, demonstrating superior performance in accuracy testing with an average accuracy of 98.76% for height and 99.21% for weight measurements, compared to Product B's 95.42% and 96.85%, respectively. These findings validate the effectiveness of the DSS methods used, providing a reliable approach for selecting IoT-based healthcare devices. This study offers a practical decision-making framework for Posyandu and other healthcare facilities to ensure accurate and efficient child growth monitoring.

Keyword: Decision Support System (DSS); AHP; Weighted Product (WP); TOPSIS; IoT-based Anthropometric Measuring Device; Stunting Prevention.

1. Introduction

Stunting remains one of national health issues that continues to be a focus of Indonesian government. The government promotes regular toodler growth monitoring to support stunting early detection and prevention. As an archipelagic country with a vast geographical area, Indonesia relies on community-based health post, known as Pos pelayanan terpadu or Posyandu, to conduct growth measurements. Posyandu serves as the frontline in stunting prevention effort across the country. Posyandu all over the country managed by a local volunteers selected from village communities throughout Indonesia. The toddler growth measurement process conducted at Posyandu is currently the most effective method for monitoring stunting prevention at the grassroots level [1-3]. However, several challenges can be find in the field: (i) Measurements are conducted by Posyandu volunteers and cadres who are not healthcare professionals, making them prone to measurement errors, (ii) Measurement records are still manually written on paper forms, which increases the risk of monitoring errors.

An IoT-based anthropometric measuring devices which emerged as a promising solution to address the measurement limitation in Posyandu. IoT-based anthropometric measuring devices offer real-time data collection, automted recording and enhanced measurement accuracy. These advantages making them highly suitable for decentralized health system such as Posyandu. Previous researches showed that these technologies demonstrated the potential to improve growth monitoring outcomes and support early intervention strategies for toddlers at risk of stunting [4-5].

Design, manufacturing and selecting the most appropriate IoT-based anthropometric tool to be used by Posyandu cadres require multi-criteria decision-making, considering factors such as accuracy, usability, connectivity, cost, and sustainability. Decision Support System (DSS) methods provide a structured framework for this purpose, allowing for systematic evaluation and prioritization of alternatives [6-7]. This study employ three well-established DSS technique, including: Weighted Product (WP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and Analytic Hierarchy Process (AHP), to analyze and rank user preferences for IoT-based anthropometric measuring devices suitable to Indonesia's Posyandu environment.

Recent studies related to these three methods findings conclude that each methods have distinct advantages [8-10]. Multiplicative weighting of criteria can be analized utilizing WP method, meanwhile TOPSIS enables proximity-based ranking relative to ideal and negative-ideal solutions [9] and AHP supports expert-driven pairwise comparisons with hierarchical structuring [10]. These three methods have proven applicability in healthcare technology evaluation and provide a robust foundation for selecting context-appropriate solutions.

Several studies related to IoT technologies for anthropometric measurements have begun to emerge [4]. However, only few studies systematically compared multiple products using structured decision-making models. Most prior research only highlights device functionality [11] or accuracy [12] without evaluating their comparative suitability for community-based health services like Posyandu. As for DSS methods, prior study in the field of health technology decision-making utilize only single-method DSS approaches, such as WP [6] or TOPSIS [9]. Anthropometric measurement conducted in Posyandu system is a complex scenario with several challenges related to its accuracy and user friendly features. The lack of integrated multi-criteria models limits the robustness and generalizability of results, particularly when addressing such complicated evaluation scenarios that involve both qualitative and quantitative criteria. There are no previous research, to the best of our knowledge, that applied hybrid DSS method which combined AHP, WP and TOPSIS in order to support decision making of IoT-based anthropometric measuring devices selection. Posyandu role with their cadres volunteer as a central actor in early stunting detection is underrepresented in decision-support literature. Despite evidence showing that Posyandu is critical to the success of Indonesia's national stunting reduction strategy [13], there is a lack of targeted evaluations on the suitability of measurement tools used in these local settings. Research has largely focused on nutritional or behavioral interventions [14], rather than the effectiveness of the technological tools that support early identification and monitoring. This study addresses those identified gap by developing and applying a novel hybrid DSS framework that integrates AHP, WP, and TOPSIS to analyze product preferences for IoT-based anthropometric measuring devices suitable for Posyandu.

This study aims to develop a comprehensive decision framework for IoT-based anthropometric measuring device evaluation by DSS variation methods integration. This research involves two IoT-based anthropometric measuring device product that were design, manufactured and tested by students as an implementation of project-based learning.

This research offers novel contribution on IoT-based anthropometric measuring device at community level. This research evaluates IoT devices intended for Posyandu use, emphasizing ease of use, accessibility, and data integration, which are vital in low-resource, non-clinical environments. Optimization of technology adoption for Posyandu cadres, placed this study ligns directly with

Indonesia's strategic plan to reduce stunting through early, accurate, and regular anthropometric monitoring.

2. Method

Three Multi Criteria Decision Making (MDCM) methods integration —AHP, WP and TOPSIS —were implemented in order to evaluate product preferences for IoT-based anthropometric measuring devices used in toddler growth monitoring. This research process was carried out through collaboration between lecturers and students from two different disciplines, i.e. Mechanical engineering and Accounting. Research methodology illustrated in Figure 1.

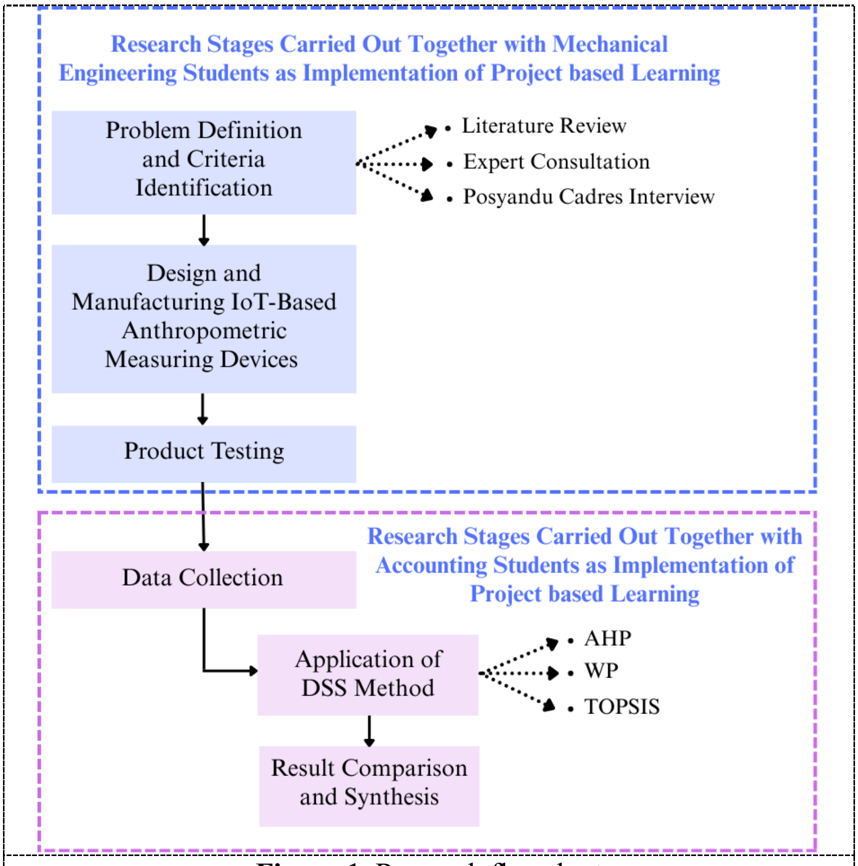

Figure 1. Research flowchart

2.1. Problem Definition and Criteria Identification

The first stage involves defining the decision problem: selecting the most suitable IoT-based anthropometric measurement device for use in Posyandu. Meanwhile, criteria identification carried out through literature review, expert consultation such as pediatrician and interview with Posyandu cadres volunteer. A set of evaluation criteria is identified at this stage, including: Measurement accuracy, ease of use, data connectivity, durability, cost-effectiveness, maintenance requirements and compability with Posyandu workflows.

2.2. Design and Manufacturing IoT-Based Anthropometric Measuring Devices

This study involves design and manufacturing of two IoT-based anthropometric measuring devices, as work result of mechanical engineering students whom divided into two groups. Those product labelled as product A and product B. These devices were developed based on criteria identification result and facilitate accurate, efficient, and real-time monitoring of toddler growth data, specifically height and weight, at Posyandu. Figure 2 shows several stages, including system design, component selection, device assembly, and software development.

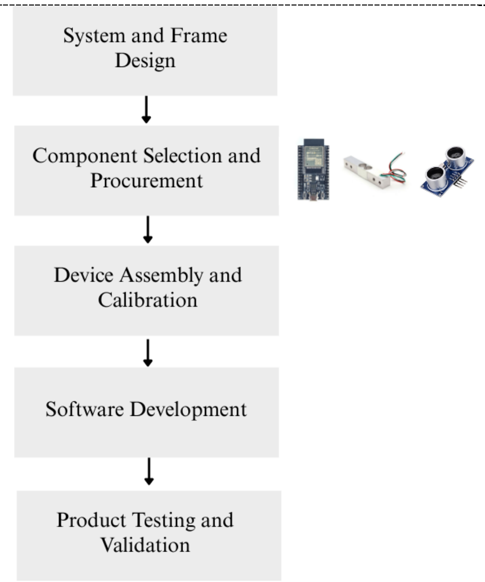

Figure 2. Design and manufacturing of IoT-based anthropometric measuring devices stages

2.2.1. System and Frame Design. Both IoT-based products was designed to measure, process, and record toodler anthropometric data. Each devices consist of main components, including: (i) Measurement sensors, weight measurement sensor such as load cell and ultrasonic sensor for height measurement; (ii) Microcontroller, an ESP32, which low cost and versatile IoT-capable microcontroller used for data processing and wireless communication; (iii) Power supply, consist of rechargeable battery system to ensure device mobility and continuous operation at Posyandu; (iv) User interface, using an Android-based mobile application that displays measurement results, including the child's weight, height, and growth chart; (vi) Cloud storage, a cloud server for storage and analysis where data is transmitted via Wi-Fi to.

2.2.2. Component Selection and Procurement. Sensor selection is an important process where high-accuracy load cells and ultrasonic sensors were selected to ensure reliable measurements. ESP32 microcontroller was chosen due to its built-in Wi-Fi ability.

2.2.3. Device Assembly and Calibration. The device components were assembled on a frame. Each sensor was positioned in order to ensure accurate reading. Sensor calibration was conducted using standard weight and height device.

2.2.4. Software Development. The IoT software was developed based on Android application. The application consist of several features: Input fields for child and parent information data (Name, age, address, etc), Real-time display of weight and height data, and children growth plotting

2.2.5. Device Testing and Validation. Those products then tested under simulated Posyandu conditions to ensure measurement accuracy and system reliability. Measurement then validated using standard tools (traditional weight scales and stadiometers) to ensure device accuracy. Connectivity tests were also performed to ensure smooth data transmission to the cloud.

2.3. Product Testing in Posyandu

Both IoT-based product were tested in Posyandu Mawar located in Semarang, Central Java, Indonesia. The testing of this product aims to train Posyandu cadres to become familiar with the product and be able to use it effectively. In addition, the product is tested in a real-world environment to identify any shortcomings, which can then be improved for future use.

2.4. Data Collection

Data collected using two methods i.e. expert interviews and user preferences surveys. Experts interview including public health officers, pediatricians, and Posyandu cadres volunteer. Meanwhile, user preferences surveys distributed to Posyandu volunteers who have experience using both products at testing.

2.5. Application of DSS Methods

This study employs and integrated three DSS methods to analyze product preferences of IoT-based anthropometric measuring devices for toddlers: AHP, WP, and TOPSIS. Each of these methods offers different and unique capabilities in decision-making and evaluation.

2.5.1. AHP

AHP is a multi-criteria decision-making method that uses pairwise comparisons to determine the relative importance of criteria. Equation (1) shows pairwise comparison matrix which is created to compare the relative importance of criteria [15].

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{bmatrix} \tag{1}$$

Each element then normalized by dividing by the sum of its column. The weights of each criterion are determined by averaging the normalized values of each row. Then the consistency of judgement is validated using Equation (2), where CI is the consistency index and RI is random index [16].

$$CR = \frac{CI}{RI} \tag{2}$$

2.5.2. WP

With WP method, each criterion value is raised to the power of its assigned weight, see Equation (3). WP applies a multiplicative model to rank alternatives based on criteria weights [17].

$$V_{ij} = X_{ij}^{wj} \tag{3}$$

Then, product of all weighted values for each alternative is calculated using Equation (4).

$$S_i = \prod_{j=1}^{n} V_{ij} \tag{4}$$

2.5.3. TOPSIS

Equation (5) shows how to normalized each value in TOPSIS. TOPSIS ranks alternatives based on their proximity to an ideal solution [18-19].

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (5)$$

Then, each value is normalized. The best and worst values for each criterion can be defined and distance can be calculated using Equation (6) and (7).

$$D_i^+ = \sqrt{\sum\nolimits_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2} \quad (6)$$

$$D_i^- = \sqrt{\sum\nolimits_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \quad (7)$$

The preference value for each alternative is determined using Equation (8)

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (8)$$

These three methods are combined in this study to provide a comprehensive and robust evaluation of IoT-based anthropometric measuring devices.

2.6. Result Comparison and Synthesis

The rankings from WP, AHP, and TOPSIS are compared to identify consistent preferences or discrepancies. A final recommendation is made based on the aggregated insights, emphasizing both expert judgment and quantitative evaluation.

3. Result and Discussion

This study result focus on IoT-based anthropometric measuring devices preferences analysis using integration of three DSS method.

3.1. Problem Definition and Criteria Identification

Criteria identification as result from expert consultation such as pediatrician and interview with Posyandu cadres volunteer can be seen in Table 1.

Table 1. Criteria identification for evaluating IoT-based anthropometric devices for toddlers

Code	Criteria	Description
C1	Measurement accuracy	Precision in weight and height measurement
C2	User friendly	User-friendliness for non-medical volunteers
C3	Device durability	Device resistance prone to wear and harsh environment
C4	IoT Connectivity	Ability to send/store data digitally
C5	Cost	Unit affordability

3.2. Design and Manufacturing IoT-Based Anthropometric Measuring Devices

The design of the IoT-based anthropometric measuring device is divided into two main sections: the design of the electrical, and the design of the device frame. The design process was carried out based on the criteria identified in Table 1. Design result of the IoT-based anthropometric measuring device: Product A (Figure 3) and Product B (Figure 4). This design conducted using computer aided design

(CAD) sofware. Meanwhile the elctrical system design result shown in Figure 5 (Product A) and Figure 6 (Product B)

Figure 3. Product A

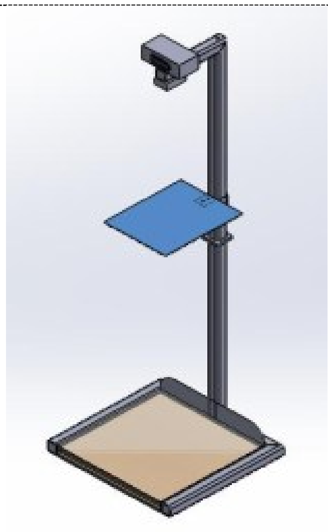

Figure 4. Product B

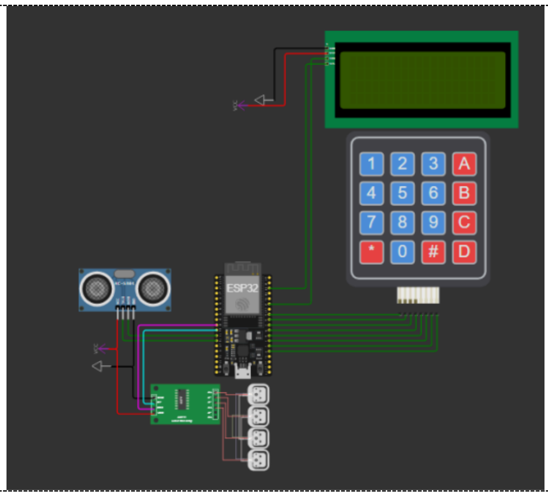

Figure 5. Electrical design system for Product A

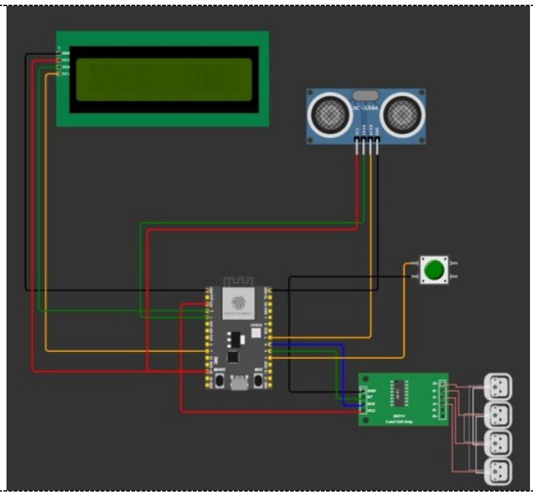

Figure 6. Electrical design system for Product B

3.3. Product Testing in Posyandu

The product testing conducted at the Posyandu aims to assess the accuracy level in the actual environment where the device will be used. Figure 7 illustrates the accuracy comparison graph between Product A and Product B.

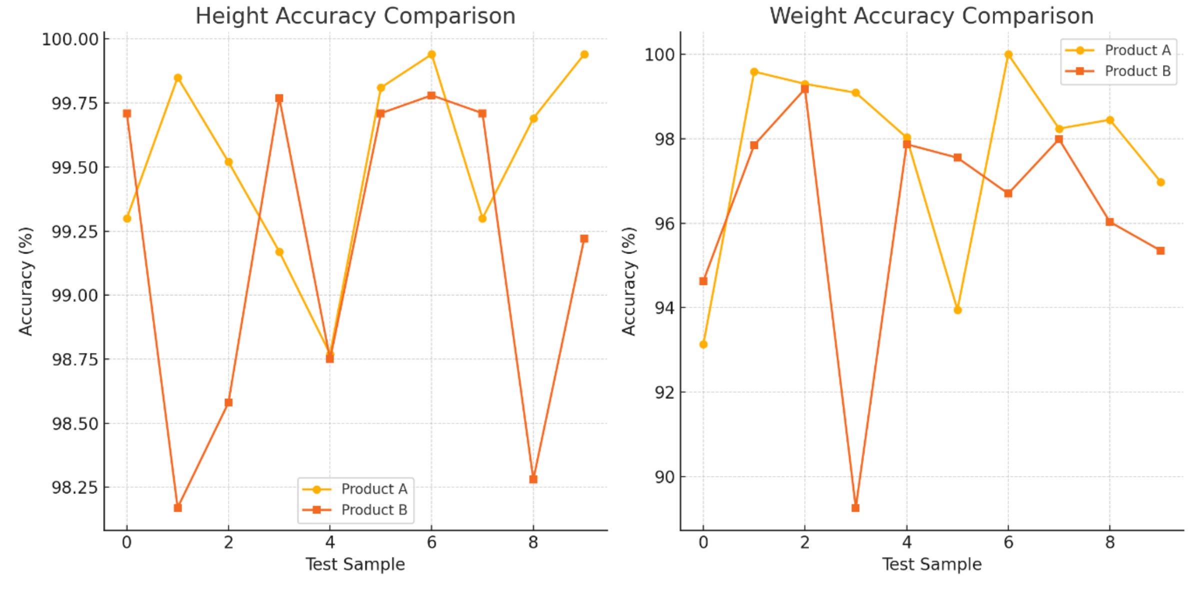

Figure 7. Height and weight accuracy comparison between Product A and Product B

The accuracy testing results, as visualized in Figure 7, reveal that Product A consistently outperforms Product B in terms of both height and weight measurement accuracy. Product A maintains a higher and more stable accuracy across all test samples for height measurement, with an average accuracy of 98.76%, compared to Product B's 95.42%. This suggests that Product A's sensor and calibration are more reliable, which is critical in ensuring accurate growth monitoring. Product A also outperforms Product B, achieving an average accuracy of 99.21%, while Product B achieves 96.85%. The lower accuracy of Product B can be attributed to larger variations in recorded values, which may be due to sensor precision or calibration issues.

3.4. DSS Method Comparison and Synthesis

The AHP method was used to determine the weight of each criterion based on pairwise comparisons. The consistency ratio (CR) was calculated and found to be within the acceptable limit (CR < 0.1), ensuring reliable weighting. The final weight of each criterion is presented in Table 2.

Table 2. AHP criteria weight

Criteria	Weight
Measurement accuracy	0.30
User friendly	0.25
Device durability	0.20
IoT Connectivity	0.15
Cost	0.10

The WP method was applied using the weighted criteria values from AHP, meanwhile TOPSIS method evaluated the alternatives based on their distance to the ideal and negative-ideal solutions. The resulting preferences values for WP and TOPSIS methods are shown in Table 3.

Table 3. AHP and TOPSIS preferences score

Product	WP Preference Score	TOPSIS Preference Score
Product A	0.825	0.730
Product A	0.778	0.690

The application of AHP, WP, and TOPSIS methods in this study consistently identified Product A as the preferred IoT-based anthropometric measuring device over Product B, primarily due to its superior accuracy and ease of use. These findings align with those from other studies employing similar MCDM approaches.

Comparative studies [20-21] further support the effectiveness of AHP, WP, and TOPSIS methods in similar contexts, reinforcing the validity of this study's approach. The findings can guide the design of future IoT-based healthcare devices, ensuring that criteria prioritization aligns with user needs.

4. Conclusion

This study implemented three Decision Support System (DSS) methods — AHP, WP, and TOPSIS — to analyze product preferences for IoT-based anthropometric measuring devices. The analysis consistently identified Product A as the preferred choice over Product B based on the criteria of accuracy, ease of use, durability, connectivity, and cost. This finding was further validated by accuracy testing, where Product A demonstrated superior performance with higher average accuracy for both height (98.76%) and weight (99.21%) measurements, compared to Product B (95.42% for height and 96.85% for weight).

The integration of AHP, WP, and TOPSIS methods proved effective in identifying the most suitable IoT-based anthropometric measuring device, ensuring that the final choice aligns with user needs in terms of performance and reliability. The consistency between the DSS results and the accuracy testing highlights the robustness of the DSS approach used in this study.

There are future studies possibility which can further enhance this approach by: Exploring additional criteria such as data security, battery life, and user interface design, which are crucial for IoT devices in healthcare, or Expanding the scope to evaluate more IoT-based healthcare devices, including those for other age groups (e.g., elderly care).

5. References

[1] Rospiati, Era DP and Urnia EE 2023 *International Journal of Nursing and Midwifery Science* The impact of community-based programs on maternal and child health outcomes **7(2A)** 30-4

[2] Astuti SJW, Dwiningwarni SS and Atmojo S 2025 *Dialogues in Health* Modeling environmental interactions and collaborative interventions for childhood stunting: a case from Indonesia **6** 100206

[3] Koka EM, Santono H and Sudaryati E 2022 *Warta LPM* Empowerment of posyandu cadres in detecting and preventing stunting **25(4)** 514-22

[4] Sofie M, Olla PK and Kusumaningtyas P 2023 *Indonesian Journal of Electronics, Electromedical Engineering, and Medical Informatics* An IoT-based baby scales for stunting monitoring in Indonesia **5(4)** 217-23

[5] Vincent ACSR and Sengan S 2024 *Scientific Reports* Effective clinical decision support implementation using a multi filter and wrapper optimisation model for Internet of Things based healthcare data **14:21820** 1-19

[6] Sari M and Susianto D 2023 *International Journal of Information System and Computer Science* Decision support system for determining indigent public health insurance participants with weighted product method in pringsewu **7(1)** 70-7

[7] Hasani MF, Sihotang EFA, Pratama GD, Kurniawan A and Utama DN 2023 *Journal of Theoretical and Applied Information Technology* Systematic literature review of decision support system for social media **101(2)** 1020-28

[8] Rosari A, Julianto J, Larasati AD, Pramesti LA, Triwiyanto, *et al* 2024 *International Journal of Advanced Health Science and Technology* Developing a nutritional assessment tool for toddlers using anthropometry and IoT technology **4(2)** 67-71

[9] Riswanto E, Melany DR, Wiratama and Syafrianto 2020 Journal of Physics: Conference Series TOPSIS method for decision support systems in determining the interests of medical student **1577(2020)** 1-6

[10] Al Awadh M 2022 Sustanability Utilizing Multi-Criteria Decision Making to Evaluate the Quality of Healthcare Services **14(19)** 1-21

[11] Fajrian AH, Nurmalasari RR, Kamelia L and Fitriani PD 2024 *10th International Conference on Wireless and Telematics (ICWT)* ANTIS: Automatic and Anthropometric Measurement and Weight IoT-Monitoring for Enhanced Infant Nutrition Assessment Using Dual Sensor and Fuzzy Logic 1-6

[12] Ardianto ET, Elisanti AD and Husin 2022 *Proceedings of the 2nd International Conference on Social Science, Humanity and Public Health (ICOSHIP 2021)* Arduino and android-based anthropometric detection tools for Indonesian children 254-59

[13] Miranda AV, Nugraha RR, Sirmareza T, Rastuti M, Asmara R, *et al* 2024 *Developmental Behavioral & Community Pediatrics* Improving stunting prevention program through community healthcare workers training and home-based growth monitoring: a quality improvement model **64(6)** 536-45

[14] Sutinbuk D, Nugraheni SA, Rahfiludin MZ and Setyaningsih Y 2024 *Short Communication* Effectiveness of ERKADUTA model to increase stunting prevention behaviors among mothers with toddlers in Indonesia: A quasi-experiment **4(1)** 1-8

[15] Irawan A, Rohaniah R, Sulistiani H and Priandika T 2019 *Jurnal Tekno Kompak* Sistem pendukung keputusan untuk pemilihan tempat servis komputer di kota bandar lampung menggunakan metode ahp **13(1)** 30-5

[16] Ramadhan MD and Marlinda L 2022 Sinkron: Jurnal dan Penelitian Teknik Informatika Decision support system for selecting study programs using the AHP method **6(4)** 2547-55

[17] Fitriyani II, Agustina NN and Fajarianti AN 2022 Iota The weighted product implementation in selection of superior jersey materials in gorich industry and production **2(3)** 198-209

[18] Chakraborty S 2021 *Engrxiv Engineering Archive* TOPSIS and modified TOPSIS: a comparative analysis 1-14

[19] Rahim R, Supiyandi S, Siahaan APU, Listyorini T, Utomo AP *et al* 2018 *Proceeding of 2nd International Conference on Statistics, Mathematics, Teaching, and Research* TOPSIS method application for decision support system in internal control for selecting best employees **1028(2018)** 012052

[20] Bahri S, and Siregar MU 2023 *Jurnal Nasional Pendidikan Teknik Informatika: JANAPATI* Accuracy analysis of WP, AHP-WP, entropy-TOPSIS methods in determining majors **12(3)** 406-415

[21] Tariq MI, Mian NA, Sohail A, Alyas T, and Ahmad R 2020 *Mobile Information Systems* Evaluation of the challenges in the internet of medical things with multicriteria decision making (AHP and TOPSIS) to overcome its obstruction under fuzzy environment **2020(1)** 8815651

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