KEMAS 21 (2) (2025) 261-271

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Environmental Factors and Efficacy of Castor Seed Influencing Aedes aegypti Larval Presence

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Article Info

Article History:
Submitted: November 2024
Accepted: September 2025
Published: October 2025

Keywords:
Aedes aegypti;
castor seed; larvicide

DOI
https://doi.org/10.15294/kemas.v21i2.16069

Abstract

Dengue hemorrhagic fever (DHF) is a major global health challenge, especially in areas endemic to the *Aedes aegypti* mosquito. This study analyzes the environmental factors influencing larval presence and investigates the effectiveness of natural larvicides from castor seed (*Ricinus communis*) in controlling *Ae. aegypti* mosquito larvae. A cross-sectional survey of households by purposive sampling between those located near and far from public places, and a quasi-experimental study comparing households in the intervention group (using castor seed powder larvicide) with those in the comparison group (not using castor seed powder larvicide) were conducted in Medan Amplas District, Medan City. The study found that location significantly impacts mosquito larvae (p = 0.045, OR 3.26, 95% CI), with households near public places at higher risk. Applying castor seed-based natural larvicide at 100 mg/L of water (p = 0.0001, OR 37.76, 95% CI 17.9-79.2) significantly reduced larvae, with a 37.76-fold higher likelihood of larval absence than the comparison group. Notably, the use of castor seed powder demonstrated exceptional effectiveness in reducing the presence of *Ae. aegypti* mosquito larvae. These findings highlight the potential of castor seed natural larvicides as a sustainable and environmentally friendly alternative to chemical larvicides, particularly for households near public places.

Introduction

Dengue hemorrhagic fever (DHF) is a severe case of dengue fever that can be fatal. It is caused by the dengue virus spread by the *Aedes aegypti* mosquito. Currently, cases of DHF occur in more than 100 countries in regions recognized by the World Health Organization (WHO), which include Africa, the Americas, the Eastern Mediterranean, Southeast Asia, and the Western Pacific. The regions most severely affected by DHF are the Americas, Southeast Asia, and the Western Pacific, with Asia contributing to approximately 70% of the global disease burden (World Health Organization, 2023).

Based on primary DHF data from the Ministry of Health of the Republic of Indonesia, the number of DHF cases in 2020 amounted to 103,509. Meanwhile, the number of DHF-related fatalities in the same year was 725 victims, with a case fatality rate (CFR) of 0.70% and an incidence rate (IR) of 38.15% per 100,000 population (Ministry of Health of the Republic of Indonesia, 2021). Dengue fever cases occur in nearly every region of Indonesia, including North Sumatra. The incidence rate of DHF has experienced consecutive declines from 2019 to 2021. In 2019, the DHF incidence rate was 53.09 per 100,000 population. The CFR of DHF in 2020 was 0.2%, a reduction from the 0.3% CFR in 2019. In Medan, one of the municipalities in the province of North Sumatra, the number of DHF cases, based on data from the Central Statistics Agency for

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pISSN 1858-1196
eISSN 2355-3596

2020, amounted to 1,068 cases (Ministry of Health of the Republic of Indonesia, 2022).

Research conducted by Baskoro *et al*. (2017) in Yogyakarta, Indonesia, showed that various physical environmental variables influenced the number of dengue vector mosquitoes, the condition of the houses, occupancy density, and vegetation (Baskoro *et al*., 2017). Female *Aedes aegypti* mosquitoes select freshwater breeding sites near human settlements, as high salinity is fatal to their offspring, making water purity a key factor in oviposition (Matthews *et al*., 2019). Water storage containers, especially crocks, were identified as the primary breeding habitat for *Ae. aegypti* larvae. In addition, factors such as the use of bed canopies, unemployment, the volume of water storage, and the interaction between the amount of garbage collected and rainfall two weeks before sampling were positively correlated with larvae (Ha *et al*., 2021; Ferede *et al*., 2018; Vannavong *et al*., 2017).

Governments globally employ an Integrated Mosquito Management (IMM) approach to control mosquitoes. Monitoring mosquito breeding sites can significantly reduce mosquito populations within communities (Centers for Diseases Control and Prevention, 2022). Professionals engage in mosquito control by monitoring mosquito populations, eliminating mosquito breeding sites (Centers for Diseases Control and Prevention, 2022; World Health Organization, 2023), managing mosquito larvae and pupae, controlling adult mosquitoes, and monitoring mosquito control efforts (World Health Organization, 2017).

The rapid reproduction from the larval stage to adult mosquitoes highlights the critical need for mosquito larval control efforts (Evans *et al*., 2023; Linenberg *et al*., 2016). By focusing on the early stages, larval source management (LSM) plays a crucial role in integrated mosquito control programs (Dusfour & Chaney, 2022). In addition to the methods mentioned earlier, another known approach is using larvicides, which can be chemical or natural. The most well-known chemical larvicide to the general public is temephos. However, the long-term use of temephos has led to mosquito larvae developing resistance to this larvicide (Adhikari & Khanikor, 2021; Piedra *et al*., 2024; Bellinato *et al*., 2016). According to a study conducted by Adhikari & Khanikor (2021) in India, temephos exhibited a dose-dependent effect, with larval mortality rates changing as the number of generations increased. At a concentration of 2 ppm, larval mortality remained at 100% until the 9th filial generation but gradually declined to only 22.66% by the 28th filial generation. The LC50 value of temephos initially showed a decreasing trend up to the 9th filial generation. However, by the 28th filial generation, the LC50 value had increased by 7.83-fold. Temephos resistance is also a global issue, specifically in Peru. Research conducted by Palomino *et al*. in 2022 indicates that out of 39 field populations of *Ae. aegypti* tested for temephos resistance, 11 exhibited high resistance levels with a resistance ratio (RR) exceeding 10 (Palomino *et al*., 2022).

Suppose the continuous increase in the usage dosage of temephos occurs without implementing a new insecticide replacement program. In that case, it harms public health and the environment. Furthermore, temephos can also endanger non-target animals (Satriawan *et al*., 2019). There is a need for alternative solutions in larvicide usage to reduce these larvae (Prabakaran *et al*., 2017). Many researchers are increasingly conducting experiments with natural larvicides(de Souza *et al*., 2019; Milugo *et al*., 2021; Wahyuni *et al*., 2019). From the research on the use of natural larvicides from red ginger extract, the higher the concentration of extract used, the greater the mortality rate of *Ae. aegypti* larvae. The highest mortality rate was recorded at a 100% concentration, while the lowest was observed at 60%. These results remained consistent after five repetitions, with each repetition lasting for 24 hours (Boekoesoe & Ahmad, 2022). The combination of papaya leaf juice and hay infusion can also serve as both an attractant and a bioinsecticide against *Ae. aegypti* mosquitoes (Cahyati *et al*., 2017).

Plants naturally produce chemical compounds to defend against pathogenic microorganisms and insects. These biologically active chemical compounds, known as 'phytochemicals,' serve as repellents, toxins, feeding deterrents, and growth regulators against insects (Bekele, 2018; Demirak & Canpolat, 2022; Gajger & Dar, 2021). Natural

larvicides have proven to be effective in killing *Ae. aegypti* mosquito larvae include essential oils, saponins, and flavonoids (Sanei-Dehkordi *et al*., 2024; Wahyuni *et al*., 2019). A literature review conducted by Pavela *et al*. (2019) identified 29 plant extracts that have proven effective as natural mosquito larvicides, including castor seed (*Ricinus communis*), in eradicating *Ae. aegypti* larvae (Pavela *et al*., 2019). *Ricinus communis*, commonly known as castor seed or oil plant, belongs to the *Euphorbiaceae* family, *Ricinus* genus, and *Ricinae* tribe. This widespread plant can be found worldwide in tropical, subtropical, and warm-climate areas (Patel *et al*., 2016; Subramaniyan, 2020). *Ricinus communis* also exhibits robust adaptability to different weather conditions, with a critical characteristic being its ability to thrive in marginal soils (Osorio-González *et al*., 2020). Building upon prior findings that suggest castor seed extracts are more potent in mosquito eradication (Wamaket *et al*., 2018). This research aims to explore castor seeds' potential as agents for reducing *Ae. aegypti* mosquito larvae.

Castor seed extract also contains ricin compounds, a natural toxin found in castor seeds that can be powder, mist, pellets, dissolved in water, or weak acid (Centers for Disease Control and Prevention, 2018). Extracts from the leaves and seeds of *Ricinus communis* have been shown to kill *Ae. aegypti* mosquito larvae, with seed extracts being more effective than leaf extracts. Castor seed extract has also been used for non-target organisms, such as Guppy fish, as it did not exhibit significant effects after 24 or 48 hours of exposure at LC50 and LC90 values (Sogan *et al*., 2018). The objectives of this study were to analyse environmental factors affecting the presence of larvae and the effectiveness of natural larvicides derived from castor seed in reducing the presence of *Ae. aegypti* mosquito larvae.

Method

This study used two design approaches. Namely, cross-sectional and experimental. Environmental variables and larval presence were measured comprehensively through a cross-sectional design, while the effectiveness of the intervention was tested through a quasi-experimental design. The population for this research comprised all households in the Medan Amplas District, totaling 29,461 households. A sample size of 260 households was selected using purposive sampling. Of these, 130 were far away, and 130 were near public places. For the quasi-experiment, 130 households were assigned to the intervention group and 130 to the comparison group. The intervention group received the application of castor seed powder at a concentration of 100 mg/L of water in households. Data collection methods employed in this study included observation sheets and questionnaires.

The independent variables in this research were the application of castor seed larvicide using ovitraps and environmental conditions, which consist of location (proximity to public facilities), house type, housing density, the presence of ventilation, habits regarding ventilation opening, the presence of wire mesh on ventilation openings, unused goods stacking, the presence of hanging clothes, the practice of draining water containers, and the practice of covering water containers. The dependent variable in this research was the presence of *Ae. aegypti* mosquito larvae in containers. Data analysis for the variables was conducted using the Chi-Square test, logistic regression, and McNemar at a significance level of 5%. During the research, the enumerator team was equipped with informed consent forms as part of the ethical clearance documentation issued by the Health Research Ethics Committee of Universitas Sumatera Utara, with reference number 937/KEPK/USU/2023.

The measured variables in the cross-sectional design include dependent and independent variables. The dependent variable was the presence of larvae measured indoors and outdoors using a flashlight to detect the presence of larvae in each water container. The independent variables consisted of environmental variables that encompassed several aspects. Firstly, location variables were divided into near and far from public places. This category was determined based on public areas throughout the location, such as schools, markets, and health centers. Secondly, house types were divided into permanent and non-permanent. Permanent houses had brick walls,

cement or ceramic floors, and tiled roofs, while non-permanent houses had wooden or bamboo walls, dirt floors, and zinc or asbestos roofs.

Furthermore, house density was measured based on the number of family members living in one house. If there is more than one householder in a home or the living area per person is less than 9 m^2, the house is categorized as overcrowded. Otherwise, it is classified as non-overcrowded if it is below these limits. Ventilation was measured by categorizing the presence or absence of ventilation (windows and vents). Wire mesh presence is measured by whether or not there is wire mesh in the house's ventilation. Opening of ventilation was measured as yes or no, which determined whether ventilation (including windows) was opened or closed at all times. Then, the stacking of unused goods was measured by the category of their presence or absence in the house. Hanging clothes was measured by whether clothes were hung in the house or not. Furthermore, covering the water container was measured by whether the water storage container was closed or not. The draining water container variable was measured by whether each water container was drained or not. If it is done once a week, it is categorized as draining, but if it is not done accordingly, it is classified as not draining.

In the experimental design, the intervention group applied castor seed powder at a concentration of 100 mg/L of water using ovitraps, while the comparison group used ovitraps filled with water only. Chahaya *et al.* (2024) previously studied this dosage in Medan City and found it to be the most effective in reducing the presence of the larvae (Chahaya *et al.*, 2024). The use of ovitraps is also effective for *Ae. aegypti* mosquitoes to lay eggs consistent with research conducted by Cahyati & Siyam, (2019) in Semarang, which showed that the most preferred containers for the mosquitoes to lay eggs were the ones made of plastic and metal. Measurements in both groups on day 0 (pre-treatment) and day 7 (post-treatment) to assess the effectiveness of the larvicide in reducing the presence of larvae (Cahyati & Siyam, 2019). Data analysis was conducted in several stages. In the cross-sectional study, the chi-square test was first used to assess the effect of environmental variables on the presence of *the* larvae. Next, logistic regression was performed to identify the environmental variables that most significantly influenced larvae's presence. In the quasi-experimental analysis, the chi-square and McNemar tests were used to evaluate the effectiveness of applying castor bean larvicide with ovitraps. These tests compared pre-treatment and post-treatment results to assess significant changes in the larval population following the intervention.

Result and Discussion

Table 1 presents the findings to identify environmental factors associated with larval presence. Out of 260 houses, the presence of *Ae. aegypti* larvae were highest in houses near public places, with 126 houses (96.9%). Additionally, most larvae were found in permanent houses, totaling 212 houses (92.6%), particularly in houses with a lower population density, where the presence of larvae was highest in 175 houses (94.6%). Moreover, houses with ventilation systems exhibited the highest larval presence, with 234 houses (93.2%), and among these, houses lacking wire mesh on the ventilation had a higher larval presence, with 169 houses (91.8%). Furthermore, among houses with ventilation, those that kept the ventilation open throughout the day showed a higher presence of larvae, with 147 houses (91.9%). In households with a significant accumulation of unused goods, the presence of larvae was more pronounced, occurring in 124 houses (89.9%). Households where clothes were not hung tended to have a higher presence of larvae, with 133 houses (93.7%). Regarding the implementation of draining and covering the water containers, houses that did not cover water containers had a higher presence of larvae, totaling 227 houses (93.4%). However, houses that had properly drained water containers had a higher presence of larvae, with 182 houses (92.9%). A significant association was observed between larval presence and both locations (p=0.045) and unused goods stacking (p=0.001).

TABLE 1. Environmental Factors Associated with Larvae's Presence

Variables	Presence of Ae. aegypti larvae		OR	95 % CI	P value
	Available	Not available			
	n (%)	n (%)			
Location					
Near public places	126 (96.9)	4 (3.1)	3.50	1.11 to 11.03	0.045*
Far from public places	117 (90.0)	13 (10.0)			
House Types					
Non-permanent	31 (100.0)	0 (0.0)	1.08	1.08 to 1.12	0.236
Permanent	212 (92.6)	17 (7.4)			
Housing Density					
Overcrowded	68 (90.7)	7 (9.3)	0.55	0.20 to 1.51	0.272
Not overcrowded	175 (94.6)	10 (5.4)			
Ventilation Presence					
Not available	9 (100.0)	0 (0.0)	1.07	1.03 to 1.10	1.000
Available	234 (93.2)	17 (6.8)			
Wire Mesh Presence					
Not available	169 (91.8)	15 (8.2)	0.30	0.06 to 1.36	0.148
Available	74 (97.4)	2 (2.6)			
Opening Ventilation					
Yes	147 (91.9)	13 (8.1)	0.47	0.14 to 1.48	0.385
No	87 (96.0)	4 (4.0)			
Unused Goods Stacking					
Available	124 (89.9)	14 (10.1)	0.22	0.06 to 0.79	0.001*
Not available	119 (97.5)	3 (2.5)			
Hanging clothes					
Available	110 (93.2)	8 (6.8)	0.93	0.34 to 2.49	1.000
Not available	133 (93.7)	9 (6.3)			
Covering water containers					
No	227 (93.4)	16 (6.6)	0.88	0.11 to 7.11	1.000
Yes	16 (94.1)	1 (5.9)			
Draining water containers					
No	61 (95.3)	3 (4.7)	1.56	0.43 to 5.62	0.771
Yes	182 (92.9)	14 (7.1)			

*Significant

TABLE 2. Logistic Regression Model 1 and Model 2

Model 1			Model 2		
Variables	**OR (95% CI)**	**P value**	**Variables**	**OR (95% CI)**	**P value**
Location	3.15 (0.98 to 10.0)	0.053	Location	3.26 (1.0 to10.3)	0.045
Unused Goods Stacking	0.25 (0.07 to 0.9)	0.037	Unused Goods Stacking	0.24 (0.06 to 0.85)	0.028
Wire Mesh Presence	0.38 (0.08 to 1.7)	0.210			

TABLE 3. Comparison of Larvae's Presence Between the Intervention and Comparison Groups

Variables		**Presence of Ae. aegypti larvae**		**OR**	**95% CI**	**P value**
		Available	**Not available**			
		n (%)	**n (%)**			
Day-0	Comparison group	123 (47.3)	7 (2.7)	1.46	0.54 to 3.97	0.616
	Intervension group	120 (46.2)	10 (3.8)			
Day-7	Comparison group	119 (45.8)	11 (4.2)	37.76	17.92 to 79.20	0.0001
	Intervension group	29 (11.2)	101 (38.8)			

TABLE 4. Comparison of larvae's presence on day 0 and day 7 in each group

Groups	**Presence of Ae. Aegypti larvae (Day-0)**	**Presence of Ae. aegypti larvae (Day-7)**			**P value**
		Available	**Not available**	**Total**	
		n	**n**	**n**	
Comparison group	Available	118	5	123	0.219
	Not available	1	6	7	
	Total	119	11	130	
Intervention group	Available	26	94	120	0.0001
	Not available	3	7	10	
	Total	29	101	130	

Table 2 presents the results of the multivariate analysis. The significance of the location variable after removing the wire mesh variable was 0.045, which means that the location and accumulation of goods affect the number of larvae. So people who live near public places have a 3.26 times greater number of larvae than those who live far from public places. Table 3 shows that on day 0, the presence of *Ae. aegypti* larvae were 94.6% in the comparison group and 92.3% in the intervention group (p-value=0.616), demonstrating no significant difference between the two groups at the outset. However, by day 7, the comparison group had 119 larvae (45.8%), while the treatment group had only 29 (11.2%). The significant difference in larval presence between the comparison and intervention groups (p=0.0001) suggests that the comparison group was 37.76 times more likely to harbor larvae than the intervention group. Table 4 presents the analysis result using the McNemar test. In the comparison group, there were 118 houses with *Ae. aegypti* larvae on both day 0 and day 7. In the group receiving the natural larvicide treatment, there were 94 houses with mosquito larvae presence, but not after the treatment. The application of natural larvicide, specifically using 100 mg of

castor seed powder per liter of water, has been proven effective in reducing the presence of *the* mosquito larvae, with a p-value of 0.0001.

Environmental factors can influence the presence of *Ae. aegypti* mosquito larvae (Baskoro *et al*., 2017). Table 1 presents the study's results, indicating that the variables affecting the presence of the larvae are located, and households accumulate unused goods. Houses near public places or in densely populated areas have a higher risk of increased mosquito density (Louis *et al*., 2016). Urban environments provide abundant habitats that support the proliferation of *Aedes aegypti*, while high human population densities can contribute to significant outbreaks of mosquito-borne diseases (Lindsay *et al*., 2017). *Ae. aegypti* mosquitoes have several characteristics and habits that make them more adaptive in densely populated urban environments (Ndenga *et al*., 2017; Herath *et al*., 2024). Research in Jakarta, Indonesia, by Hamid *et al*. (2017) also notes *Ae. aegypti* mosquitoes exhibit hematophagy behavior, actively seeking blood hosts, especially humans, during daylight hours (Hamid *et al*., 2017). This behavior exposes *Ae. aegypti* mosquitoes to humans in densely populated urban environments where human activity is intense during the day.

The findings of this study show that houses far from public areas have a 3.26 times greater tendency not to have larvae than houses near public places. This research is consistent with Louis' (2016) finding that schools, workplaces, and other public places contain 2.77 times more larvae and pupae than residential areas (95% CI) (Louis *et al*., 2016). Research conducted in the Ivory Coast, West Africa, by Zahouli *et al*. (2016) also showed the highest average number of *Ae. aegypti* was found in urban areas, precisely 1.97 ± 0.10 *Ae. aegypti*/ovitrap/week, with significantly lower average numbers found in rural and suburban areas, at 0.57 ± 0.05 and 1.20 ± 0.09 *Ae. aegypti*/ovitrap/week, respectively (Zahouli *et al*., 2016).

In addition to location, this study also suggests that the habit of piling up unused goods can create breeding grounds for mosquitoes. The analysis results reveal a significant difference in the presence of larvae between households with and without piling up unused goods (p-value=0.024). This considerable difference underscores the importance of human habits in mosquito breeding. One of the main factors contributing to mosquito proliferation in a location is poor hygiene in the home environment (Olagunju, 2023). Forsyth *et al*. (2020) conducted relevant research investigating the effect of unused goods accumulation in creating an environment conducive to mosquito breeding (Forsyth *et al*., 2020). The habit of accumulating unused goods (Samsudin *et al*., 2024), especially goods that can hold water, such as containers, flower pots, buckets, and similar objects, creates ideal conditions for *Ae. aegypti* mosquitoes to lay eggs and breed (Viswan *et al*., 2020; Newyearsi & Silviana, 2022). Research conducted in Kenya by Forsyth *et al*. (2020) revealed that the most productive mosquito breeding sites could be categorized into three groups: 1) containers with a direct or reusable purpose (e.g., buckets); 2) containers without a direct purpose but possessing reusable value (e.g., tires); and 3) containers with no direct purpose and limited reusable value. Therefore, vector control efforts to reduce container abundance and potential mosquito breeding habitats should be prioritized (Forsyth *et al*., 2020).

Despite the emphasis on environmental controls, natural larvicides have also proven effective in controlling mosquito populations. When applied to the intervention group, these larvicides resulted in slower larval movement, tremors, convulsions, and mortality (De Azevedo *et al*., 2021). The study reveals a significant difference (p=0.0001) in larvae presence between the comparison and intervention groups, with the comparison group having a 37.76 times higher likelihood of having larvae. So, the application of natural larvicides, specifically castor seed powder, at a dose of 100 mg per liter of water.

The percentage of larval mortality at various concentrations of castor oil is dose-dependent, with higher concentrations resulting in more significant larval mortality (Wamaket *et al*., 2018). The findings of a previous study conducted by Chahaya *et al*. (2024) in Medan City, North Sumatra, indicate that a dosage of castor seed larvicide at 100 mg/L is the most effective compared to other tested dosages

(Chahaya *et al*., 2024). This dosage significantly reduces the number of larvae, as evidenced by the comparison between the intervention group, which received the treatment, and the control group, which did not. The aqueous extract of *Ricinus communis* was found to have a highly detrimental larvicidal effect on *Culex pipiens* mosquitoes, causing 50% larval mortality in less than 6 hours for the second instar stage and less than 12 hours for the first instar stage (Rihane & Mellouki, 2017). Research conducted by Wachira *et al*. (2014) found that extracts from *Tithonia diversifolia* and *Ricinus communis* were the most toxic to adult female *Anopheles gambiae* mosquitoes compared to the other four test plants after a 7-day treatment, with LC50 values of 1.52 and 2.56 mg/mL, respectively (Wachira *et al*., 2014). Additionally, *Ricinus communis* and nanoparticles prepared as substitutes for chemical pesticides were highly effective against vector-linked mosquitoes (Waris *et al*., 2020).

Ricinus communis has a high percentage of monounsaturated fatty acids and is similar to other vegetable oils. Phytochemical compounds include flavonoids, cyanogenic glycosides, saponins, oxalates, phytates, alkaloids, and tannins (Yeboah *et al*., 2021). Saponins are naturally occurring compounds with diverse structural and chemical properties, widely found in various plant species. Their amphipathic nature, resulting from hydrophilic sugar moieties attached to lipophilic aglycones, grants them multiple biological and functional applications. Saponins are recognized for their foaming, emulsifying, and stabilizing properties, making them valuable in various formulations. Additionally, they exhibit bioactive characteristics, such as anti-inflammatory, antimicrobial, antiviral, anticancer, and immune-modulating effects (Timilsena *et al*., 2023). Alkaloids are organic compounds with basic properties that are widely found in plants and exhibit various biological activities in the body. These compounds play a role in regulating the nervous system and physiological responses through the inhibition of muscarinic acetylcholine receptors and also function as natural insecticides that disrupt the nervous system of insects, making them effective for pest control (Debnath *et al*., 2018).

The effectiveness of larvicide derived from *Ricinus communis* depends on controlling favorable environmental factors. In line with this study, one crucial aspect to consider is the proximity of residences to public spaces. Dwellings close to public areas, such as markets or shopping centers, are likelier to exhibit a heightened risk of disease transmission facilitated by *Ae. aegypti* (Louis *et al*., 2016). Therefore, it is essential to develop a control strategy that accounts for mosquitoes' dispersal patterns based on geographical location. Stacking habits can also impact the efficacy of control measures. Accumulated unused goods around the residence can provide an ideal breeding ground for mosquitoes, especially if they can collect rainwater (Newyearsi & Silviana, 2022). Implementing hygiene policies around the home, such as maintaining a clean yard and disposing of unused items, can significantly reduce breeding grounds for *Ae. aegypti* larvae (Praveen *et al*., 2017). If concurrent environmental control measures do not combine with castor seed larvicide usage, its effectiveness may be significantly reduced. In contrast, castor seed larvicide can decrease *Ae. aegypti* larvae in specific areas, mosquitoes may continue to reproduce in other locations not covered by the larvicide. Conversely, solely managing environmental factors without applying larvicides may not effectively address the mosquito population, as the existing larvae are not directly targeted.

Conclusion

Environmental factors, including the location of households and the accumulation of unused goods, have been identified as significant influences on the presence of these mosquitoes. The use of castor seed larvicide at a concentration of 100 mg/l of water via ovitraps has proven to be an effective method for reducing the presence of *Ae. aegypti* larvae. This study offers insights into a sustainable and environmentally friendly approach to mosquito control, particularly in high-risk areas for dengue transmission, such as household locations near public places. Future research should focus on assessing long-term impacts and exploring the integration of castor seed larvicide into comprehensive vector

management programs.

Acknowledgments

The authors thank the Directorate General of Higher Education, Ministry of Education and Culture of the Republic of Indonesia for funding and supporting our research.

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KEMAS 21 (2) (2025) 272-280

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

hpmA Gene as a Detection Method of Proteus mirabilis Bacteria using real-time Polymerase Chain Reaction

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Article Info

Article History:
Submitted: November 2024
Accepted: September 2025
Published: October 2025

Keywords:
Pathogenic bacteria; Detection method; real-time Polymerase Chain Reaction; Proteus mirabilis; hpmA gene

DOI
https://doi.org/10.15294/kemas.v21i2.16214

Abstract

Proteus mirabilis is a pathogenic bacterium that can cause gastrointestinal infections, bacteremia, and Urinary Tract Infections (UTI). Therefore, it is necessary to have a fast, sensitive, specific, and accurate detection method to identify Proteus mirabilis. This study aims to determine the confirmation, specificity, and sensitivity of the hpmA gene primer to detect Proteus mirabilis swiftly and precisely using the real-time Polymerase Chain Reaction method. Gradient Polymerase Chain Reaction results showed the hpmA primer has an amplicon length of 195 bp and an optimum annealing temperature at 60°C. The primer pair produced a Ct value of 10.40±0.18 and showed one peak in the melting curve with a Tm value of 81.84°C±0.02 by real-time PCR. In addition, the hpmA primer can distinguish target and non-target bacteria based on the variation in Ct and Tm values formed. Based on these results, the concentration of bacterial DNA detected by primers reached 3.2 pg/µL, equivalent to the concentration of target bacteria that can be detected by primers, which is 10.24×102 CFU. In the next step, the hmpA primer will be developed to detect Proteus mirabilis in artificially contaminated samples using real-time PCR

Introduction

Food is the most fundamental necessity for human life. Every individual requires food as a source of energy and various essential nutrients for the body. Quality food is characterized by high nutritional value, cleanliness, and the absence of harmful substances. However, insufficient attention to proper food handling factors can lead to contamination with pathogenic microorganisms, potentially resulting in foodborne infections. The World Health Organization (WHO) estimates that more than 600 million people get sick and 420,000 people die annually, making foodborne pathogens a serious public health issue globally (Elbehiry *et al*., 2023). The first causative agent of foodborne pathogens is pathogenic bacteria, which are caused by bacteria in the digestive tract of food consumed by humans or the ingestion of large numbers of microbes, which then live and multiply in the body (Foddai & Grant, 2020). One of the pathogenic bacteria is *Proteus mirabilis*, a gram-negative, rod-shaped, and facultative anaerobic (I Nyoman & Ni luh,

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pISSN 1858-1196
eISSN 2355-3596

2021).

Proteus mirabilis is a pathogenic bacterium that can cause gastrointestinal infections, bacteremia, and Urinary Tract Infections (UTI) (Schaffer, J. N. & Pearson, M., 2015). This bacterium can be found in contaminated meats, vegetables, and seafood (Ronanki *et al*., 2022). *Proteus mirabilis* produces hemolysins, one of which is the *hpmA* hemolysin. *hpmA* hemolysin can cause cytotoxicity that allows bacteria to enter the kidney (Lazm *et al*., 2019). In recent years, cases of food poisoning caused by *Proteus mirabilis* bacteria have been reported in China. In a case in Zhejiang Province in 1998, 256 students at a middle school were diagnosed with a foodborne infection due to *Proteus mirabilis*. A similar case in Guangxi Province in 2006 resulted in 34 people getting sick, and in Beijing in 2013 resulted in 4 people being identified with a foodborne pathogen due to *Proteus mirabilis*. According to the Datong Food and Drug Inspection and Testing Center, foodborne pathogen incidents associated with *Proteus mirabilis* accounted for 3.61% of reported foodborne pathogen incidents in Datong (Shanxi Province, China) from 2016 to 2017 (Gong *et al*., 2019). An optimal approach to bacterial detection is needed to treat this instance of a foodborne pathogen.

Research and development have been carried out on the detection of pathogenic bacteria. One of the methods is Polymerase Chain Reaction (PCR). The ideal detection method needs to qualify the main terms, which are sensitivity, specificity, fast, simple operation, and cost-effective (Priyanka *et al*., 2015). Real-time PCR (rt-PCR) is an ideal method used for identifying and measuring various microbial agents in clinical diagnostics and food safety (Kralik & Ricchi, 2017). In previous research, the detection of *Proteus mirabilis* bacteria has been completed using Multiplex PCR. But the method used is not fast and sensitive (Priyanka *et al*., 2015; Wojno *et al*., 2020). Therefore, this study aims to determine the confirmation, specificity, and sensitivity test of the *hpmA* gene primer to detect *Proteus mirabilis* swiftly and precisely using the real-time Polymerase Chain Reaction method (rt-PCR).

Methods

Primers in *Proteus mirabilis* ATCC 7002 bacteria were identified using an in-silico primer utilizing the National Center for Biotechnology Information (NCBI) website and the Primer-BLAST (Primer-Basic Local Alignment Search Tool) program. Furthermore, the selected primers will be re-analyzed using the OligoAnalyzer and NetPrimer programs to identify a secondary structure. The Macrogen Synthesis, Inc.-Korea commercial facility synthesized the designed primers. The *Proteus mirabilis* culture, designed in a kwik-stick format, was resuspended using a hydration solution and inoculated into Luria Bertani Broth (LB) media (Merck). The inoculated culture was then incubated with aeration using an Orbital Shaker-Incubator (YIHDER LM-400) set at 150 rpm and 37°C for 18-24 hours. After the incubation period, the bacterial culture was examined; the formation of turbidity in the Luria Bertani Broth (LB) indicated successful bacterial growth. For further assessment, the Optical Density (OD) at a wavelength of 600 nm was measured using a UV-Vis spectrophotometer. Furthermore, the bacterial culture obtained was inoculated in *McConkey Agar* (MCA) (Merck) at a dilution of 10^{-6} and 10^{-7} for 24 hours at 37°C.

The DNA isolation process of a pure culture of *Proteus mirabilis* bacteria was performed using the Viogene-Geno Plus Genomic. A microcentrifuge tube containing 3 mL of a pure cultivated bacteria inoculum was centrifuged (Sorvall™ Legend™ Mikro 17R Microcentrifuge) at 12,000 x g for five minutes, or until a pellet was formed. Furthermore, the Viogene-Geno Plus Genomic instructions were followed to complete the isolation procedure. After the separation of *Proteus mirabilis* bacterial DNA, nanodrop testing (Nanovue™ Plus Spectofotometer) and electrophoresis were conducted. Gradient PCR (Heal Force X960) was used to optimize the annealing temperature within the 54°C - 62°C temperature range. The test involved a 25 µL reaction mixture containing NZYTaq II 2x Green Master Mix, *Proteus mirabilis* DNA isolate, forward and reverse *hpmA* primers, and Nuclease Free Water (NFW). The amplification process consisted of 35 cycles, beginning with

an initial denaturation process at 95°C for 100 seconds, followed by denaturation at 95°C for 30 seconds, annealing at temperatures ranging from 53°C to 62°C for 30 seconds, extension at 72°C for 1 minute, and a final extension at 72°C for 10 minutes. The results of the optimization of annealing temperature will be seen using electrophoresis.

Confirmation test of *hpmA* primer for the detection of *Proteus mirabilis* bacteria using the real-time PCR method, with a concentration of target bacteria of 50 ng/µL. A 20 µL reaction mixture was prepared, including ExcelTaq 2X qPCR Master Mix, forward and reverse *hpmA* primers, a pure DNA isolate template of *Proteus mirabilis*, and Nuclease Free Water (NFW). The amplification of samples was made twice (duplo). Additionally, two negative controls consisting of Nuclease-Free Water with Master Mix (NFW+MM) and a Non-Template Control (NTC) were included in the test. The specificity test using Real-Time PCR is designed to assess the primers' ability to differentiate between *P. mirabilis* target bacteria and non-target bacteria. This test used non-target bacteria, like *Escherichia coli, Enterococcus faecalis, Shigella flexneri, Campylobacter jejuni, Enterobacter sakazakii, Pseudomonas aeruginosa, Salmonella typhi, Listeria monocytogenes, Klebsiella pneumonia,* and *Yersinia enterocolitica.* The reaction mixture was prepared in a volume of 20 µL each. The results obtained from the specificity test are represented by the Ct value and Tm value based on the amplification curve and the melting curve. The Sensitivity testing aims to determine the Limit of Detection (LoD) value of the *hpmA* gene primer pair. This test went through a series of seven dilutions of pure *Proteus mirabilis* DNA isolates. A 1 µL aliquot of pure *Proteus mirabilis* bacterial DNA was mixed with 9 µL of Nuclease Free Water (NFW) for each dilution step. The results obtained from the specificity test are represented by the concentration and Ct value based on the amplification curve and the standard curve.

Results and Discussion

Primer design for *Proteus mirabilis* ATCC 7002 bacteria targeting the *hpmA* gene fragment. This gene was selected based on its role as one of the hemolysins produced by *Proteus mirabilis* bacteria (Fox-Moon *et al*., 2015). The *hpmA* gene encodes the hpm hemolysin. The *hpmA* hemolysin is a cell-independent, calcium-independent, pore-forming protein. *hpmA* hemolysin can cause cytotoxicity that allows *Proteus mirabilis* bacteria to enter the kidney (Lazm *et al*., 2019). Primer design in the *hpmA* gene requires several parameters, such as amplicon length, primer length, dimers, % GC, melting temperature, and specificity, which have a significant impact because they are interrelated with the stability and sensitivity of primers to detect target bacteria (Bustin, *et al*., 2020), in silico results obtained that the *hpmA* gene is 4,733 base pairs (bp) in the 1,075,493 - 1,070,760 region. The designed primers had an amplicon length of 195 bp and were identified as F5'CATTACTGGGCACGCCAAAG-F3', measuring 20 bp, and R5'GCATTCCCTGCGGTAGTCTT-R3', measuring 20 bp.

Table 1. Sequence and Design of hpmA Primer Pairs

Primer	Sequences	Primer Length	Molecular Wt	TM (°C)	% GC	Self-Dimer (kcal/mol)	Hairpin (kcal/mol)	Cross dimer	Amplicon Length
hpmA-f	CATTACTGGG CACGCCAAAG	20 bp	6111,07	61,47	55	-6,02	-1,62	-3.94	195 bp
hpmA-r	AAGACTACCG CAGGGAATGC	20 bp	6075,03	59,29	55	-	-0,69		

The cultivation of *Proteus mirabilis* bacteria aims to obtain a single colony of bacteria. Luria Bertani Broth (LB) was applied to enrich the bacterial suspensions for test cultures. The results of bacterial growth on liquid medium are shown by the presence of turbidity. Using UV-VIS spectrophotometry, the optical density at a wavelength of 600 nm (OD600) was measured to show the turbidity. In bacterial analysis, 600 nm is generally used, indicating that OD correlates directly with cell concentration (McBirney *et al.,* 2016). After 18 hours of bacterial growth, the optical density value was 2,270. After that, the bacterial culture obtained was inoculated in McConkey Agar (MCA). MCA is a selective medium that contains bile salts (to inhibit gram-positive bacteria), neutral red dye (as a pH indicator to determine the presence of lactose fermentation), lactose, and peptone (Artauli *et al*., 2023). The results of *P. mirabilis* produced colourless, round, single colonies after 18 hours of incubation.

In this study, DNA extraction uses *Viogene – Geno Plus Genomic DNA Extraction Miniprep System Kit*, which consists of *Lysis solution, Proteinase K, RNAse, Wash Buffer I, Wash Buffer II,* and *Elution Buffer*. The results of the bacterial DNA isolation test are pure bacterial DNA isolates, which will be tested qualitatively and quantitatively. A qualitative test using agarose gel electrophoresis, which aims to confirm that the isolation of bacterial genomic DNA is successful, is characterized by a band that matches the size of the *P. mirabilis* bacterial genome. Electrophoresis is a method of separating proteins and nucleic acids based on their size, as early detection of an infection (Wardoyo & Badri, 2020). Electrophoresis results show that the results of *P. mirabilis* bacterial DNA isolates are more than 10,000 bp, and there is a match with the size of the whole genome of *P. mirabilis* ATCC 7002 of 3,999,612 bp based on the results of in-silico analysis so that the results of this electrophoresis can be confirmed that there is a genomic DNA isolate from the isolation of *P. mirabilis* bacterial DNA.

Furthermore, quantitative tests using a nanodrop spectrophotometer aim to determine the purity and concentration of bacterial isolates. DNA purity can be measured by the A260/A280 ratio, where the wavelength of 260 nm is the maximum wavelength of DNA that can absorb UV light, as the wavelength of 280 nm is the maximum wavelength of contaminants such as proteins and phenols that will absorb UV light (Dewanta & Mushlih, 2021). The measurement results of *P. mirabilis* isolates obtained a concentration of 160 ng/µL and a purity of 1.80. Based on the measurement, good DNA purity were obtained in the range of 1.8 - 2.0. If the purity is above 1.80, it indicates RNA contamination, and a purity below 1.80 indicates contamination with protein (Lucena-Aguilar *et al*., 2016). Based on the concentration and purity, the DNA isolation was carried out successfully and purely.

The primer annealing temperature optimization aims to determine the optimal temperature of the primer from the annealing process in real-time PCR. Hydrogen bonds are formed between the primer and the template at this stage, which can only occur if the primer and template sequences are perfectly complementary (Barnes & Lewis., 2016). In this study, the temperature range used for annealing temperature optimization was 54-62°C using gradient PCR. When the annealing temperature used is too high, the annealing process becomes suboptimal and results in low amplification products. Conversely, if the temperature is too low, non-specific amplification will occur (Ehtisham *et al*., 2016). The temperature range used is ±5°C, the melting temperature of *hpmA* primer from the results of in silico analysis (Rodríguez *et al.,* 2019). The results of the *hpmA* primer annealing temperature optimization are shown in **Figure 1**. Based on the result, the primer was able to amplify the *hpmA* gene fragment at all temperatures. This is indicated by the presence of a band at a length of 195 bp at 54-62°C; thus, this size is consistent with the in-silico size of the *hpmA* primer. At a temperature of 60°C, it is considered the optimal annealing temperature because 60°C is the standard or default temperature of the real-time PCR machine. Choosing the highest temperature within the temperature range is also to avoid the formation of non-specific amplification and the formation of dimers. It is because the higher the annealing temperature, the greater the specificity of the primer. The positive

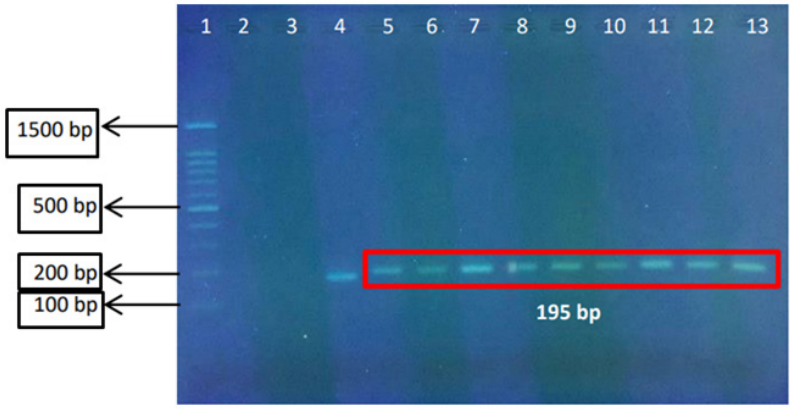

Figure 1. hpmA gene Annealing Temperature Optimization Results. (1) DNA Ladder 100 bp; (2) NTC; (3) NFW + MM (Negative control); (4) Positif control codY Bacillus subtilis 175 bp; (5) 54°C; (6) 55°C; (7) 56°C; (8) 57°C; (9) 58°C; (10) 59°C; (11) 60°C; (12) 61°C; (13) 62°C

control used is *codY Bacillus subtilis* with a size of 175 bp. There are two negative controls used, which are the NTC (*Non-Template Control*) and NFW (*Nuclease Free Water*) + MM (*Master Mix*). NTC aims to determine the presence of dimers in the primer, and NFW + MM aims to determine the absence of impurities in the PCR process.

A method for detecting and measuring different microbial agents for clinical diagnostics and food safety is real-time PCR (Kralik & Ricchi, 2017). Using the real-time PCR. The primer confirmation test using real-time PCR aims to determine the ability of primers designed to recognize and amplify target bacteria. The *hpmA* gene fragment of *P. mirabilis* was amplified using the BMS MicqPCR Cycler instrument as the target. In this study, the annealing temperature was 60°C based on the optimum results in the previous test. The confirmation test used 40 cycles, each cycle divided into three phases. They were denaturation, annealing, and extension. In the denaturation stage, the DNA is denatured at a high temperature between 92 and 98°C, causing the double-stranded DNA to separate into single-stranded DNA. Then, a temperature between 55 and 65°C allows the primers to bind to the complementary DNA template. Lastly, DNA polymerase enzymes bind to the annealed primers and synthesize a complementary DNA strand at a temperature range of 60°C to 78°C (polymerase extension) (Wu *et al.,* 2020). The results obtained in the confirmation test using RT-PCR are data in the form of an amplification curve and melting curve. The cycle threshold (Ct) value of the PCR process is examined to read the amplification curve in the test results. The cycle threshold (Ct) refers to the number of amplification cycles required for fluorescence to exceed the threshold. A lower Ct value indicates a higher amount of nucleic acid in the sample. A higher Ct value suggests a lower amount of nucleic acid, as the Ct value is inversely related to the number of nucleic acid targets present in the sample (Health Ontario, 2020). The results of the confirmation test in this study are shown in **Figure 2**.

According to the amplification curve results, the primer was able to detect the presence of *Proteus mirabilis* target bacteria with a concentration of 50 ng/µL. The primers used were *hpmA Forward* (*hpmA-f*) and *hpmA Reverse* (*hpmA-r*) primer pairs, with a concentration of 2 pmol. The appearance of Ct at cycles 10.23 and 10.58 (duplo) indicates the ability of the primer to detect target DNA in the sample. It shows that the primer successfully amplified the *hpmA* fragment of *Proteus mirabilis*. Based on the results of the positive control using *Listeria monocytogenes*, the *hly* Ct gene appeared at cycle 14.12, indicating that the reaction went well. In addition, the negative control is indicated by the appearance of NTC at cycle 28,15, which shows the formation of dimers and not contamination. It is confirmed

by the non-appearance of the NFW + MM sigmoid curve in the reaction results. The Ct value of a good NTC is 35-40 cycles. If the difference between the sample and the NTC is higher than 10 cycles, then the NTC can be tolerated (Nurjayadi *et al.* 2018). Based on the melting curve, the *P. mirabilis* sample showed one single peak, indicating the absence of non-specific amplification with TM values of 81.82°C and 81.86°C. However, if the sample produces more than one peak and several amplicons, it indicates that the designed primer is considered non-specific to the target DNA fragment or target gene (Nurjayadi *et al.*, 2018). The Tm value of the NTC was 81.16°C, indicating a difference in peaks compared to the sample attributed to GC composition factors present in both amplicons (Dorak, 2007). Furthermore, the Tm value of the positive control using *hly Listeria monocytogenes* shows a consistent value, in accordance with previous research, which is 81.67°C. Based on the temperature difference formed, it indicates that the product formed on the NTC is not the target product. So, based on the melting curve, a specific temperature is obtained to confirm the presence of *Proteus mirabilis*.

The specificity test with Real-Time

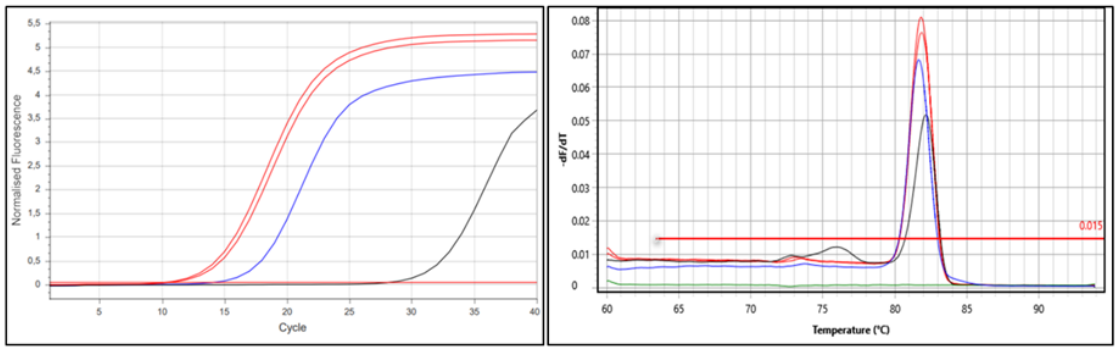

Figure 2. Amplification Curve and Melting Curve of Primer Confirmation Test. Amplification Curve (Left); Melting Curve (Right). Proteus mirabilis 2 pmol (duplo) (Red); Non-Template Control (NTC) (Black); Control Positif (L. monocytogenes) (Blue).

Table 2. Ct and Tm Value of Specificity Test

Sample	Ct	Tm (°C)
Proteus mirabilis 2 pmol (1)	11.49	82.05
Proteus mirabilis 2 pmol (2)	11.11	82.08
NTC	29.81	82.48
Control positive (*L. monocytogenes*)	17.34	81.30
NFW + MM	-	-
E. coli	27.53	82.59
C. jejuni	29.44	77.35; 83.36
C. sakazakii	28.58	82.53
E. faecalis	28.53	77.41; 83.35
K. pneumonia	28.09	83.81
L. monocytogenes	28.89	76.54; 82.49
P. aeruginosa	27.79	82.86
S. flexneri	29.04	76.54; 82.49
S. typhi	27.07	64.07; 73.80; 78.95
Y. enterolitica	27.76	82.50

PCR aims to determine the ability of primers to distinguish non-target bacteria from *P. mirabilis* target bacteria. This test is represented by an amplification curve, where the Ct value is obtained, and a melting curve, where the melting temperature (Tm) is obtained in **Table 2**. Based on the Ct values, the bacteria target *P. mirabilis* appeared at Ct at cycle 11.49 and 11.11 (duplo). Meanwhile, non-bacteria had Ct around cycle 27-29. Furthermore, the control positive was found at Ct cycle 17.34, and the control negative was found at Ct cycle 28.15. The difference in Ct between the target bacteria and the 10 non-target bacteria is 16 to 18 cycles. It can be ignored and taken as negative since the non-target bacteria and target bacteria had a Ct of more than 10 cycles (Dorak, 2007). Meanwhile, according to the Tm value, each non-target bacteria has a different Tm than the target bacteria. In non-target bacteria, the Tm value shifts, indicating the amplicon difference between the target and non-target bacteria. Furthermore, more than one Tm in non-target bacteria indicates the presence of non-specific amplification. According to the Ct value and Tm value, the *hpmA* primer can distinguish between target bacteria and 10 non-target bacteria.

The Sensitivity testing aims to determine the Limit of Detection (LoD) value of the *hpmA* gene primer pair. The initial concentration obtained from the isolation of pure DNA is 160 ng/µL. Based on the results, the smaller the concentration, the larger the resulting Ct. Because the smaller the concentration, the more cycles are needed, so the fluorescein formed passes the threshold, resulting in a larger Ct value. Therefore, there is an inverse proportional relationship between Ct value and concentration. Sensitivity test for *hpmA* primers is shown by a standard curve (**Table 3**) with equation y = -3.359 x + 16,89. The optimal slope for the standard curve is -3.32, which corresponds to 100% RT-qPCR efficiency. However, slopes ranging from -3.1 (indicating 110% efficiency) to -3.58 (indicating 90% efficiency) are also considered acceptable (Bivins, 2021). The efficiency result is 0.985, with amplification efficiencies ranging from 90% - 110% being accepted. The coefficient of determination (R^2) shows the linearity of the standard curve. The R^2 is 0.9957, showing a strong linear fit with R^2 values in the range of 0.980 to 1.00 (Bivins, 2021). PCR efficiency can be determined from the slope, with an efficiency of 0.985. Based on the amplification curve (**Table 3**), the concentration of bacterial DNA detected by primers reached 3.2 pg/µL at Ct 24.17, equivalent to the concentration of target bacteria detected by primers, which is 10.24×10^2 CFU. Based on the sensitivity test, the real-time PCR method can detect negligible sample DNA and amplify DNA specifically and accurately (Marbawati & Pramestuti, 2017).

Table 3. Concentration and Ct Value of Sensitivity Test

Sample	Concentration (ng/µL)	Ct
D0	50	11.13
D1	10	15.91
D2	2	13.27
D3	0.4	18.31
D4	0.08	21.02
D5	0.016	23.20
D6	0.0032	24.71
NTC	-	25.96
Equation y	-3.359 x + 16.89	
Efficiency	0.985	
R^2	0.9957	

Conclusion

The Rapid detection of *Proteus mirabilis* bacteria using the real-time PCR method has been successfully performed using the *hpmA* gene with an amplicon length of 195 bp at an annealing temperature of 60°C. The *hpmA* gene showed the ability to detect *Proteus mirabilis* with a Ct of 10.40±0.18 and Tm of 81.84°C±0.02. Based on the difference in Ct and Tm value, the hpmA primer was also successful in distinguishing between target and non-target bacteria. The Limit of detection for the *hpmA* primer was determined to be 3.2 pg/μL, which is equivalent to 10.24×10^2 CFU.

Acknowledgments

This research is funded by Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi through the Fundamental scheme with contract number: 064/E5/PG.02.00.PL/VI/2024 and Badan Riset Inovasi Nasional (BRIN) with the Riset Inovasi untuk Indonesia Maju (RIIM-LPDP) scheme with contract number: 2/PG.02.00.PT/LPPM/IV/2024. We would like to express our gratitude to PT Sinergi Indomitra Pratama for providing the instruments for this study, Pusat Kedokteran dan Kesehatan Kepolisian Negara Republik Indonesia, Pusat Laboratorium Forensik Negara Republik Indonesia, PT. Kimia Farma, and the Salmonella UNJ team at the Centre of Excellence for Pathogenic Bacteria Detection (PUI Pendeteksi Bakteri Patogen) LPPM UNJ for their effort. We appreciate our international partners, UTM (Universiti Teknologi Malaysia), Malaysia, and Arnold Palmer Hospital, Orlando, Florida, USA.

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KEMAS 21 (2) (2025) 281-289

Jurnal Kesehatan Masyarakat

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Breeding Site Preferences and Resistance Status of Aedes aegypti in Malang City

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Article Info

Article History:
Submitted: February 2025
Accepted: September 2025
Published: October 2025

Keywords:
Aedes aegypti; Cypermethrin; Malathion; Resistant; Vector control

DOI
https://doi.org/10.15294/kemas.v21i2.21666

Abstract

Dengue Hemorrhagic Fever (DHF) remains a significant health challenge in urban and semi-urban regions, including Malang City, Indonesia, where Aedes aegypti is the primary vector. This study aimed to identify the breeding site preferences of Ae. aegypti and assess its resistance to 0.8% malathion and 0.05% cypermethrin insecticides. Using a descriptive observational design, ovitraps were deployed in three districts to collect mosquito larvae and eggs, and interviews with residents provided additional data on breeding site preferences. Resistance tests followed WHO guidelines, with mortality rates analyzed after insecticide exposure. Results indicated that, Ae. aegypti larvae were predominantly found in bathroom water tanks (45%) and flower vases (35%). Resistance status revealed geographical variability: Ae. aegypti in District 1 were resistant to cypermethrin, while populations in Districts 2 and 3 were susceptible, with an average status of Ae. aegypti is tolerant to cypermethrin. For malathion, resistance was widespread, particularly in District 3, with an average status of Ae. aegypti to malathion is resistant. These findings suggest that the use of malathion for vector control in Malang is no longer effective, while cypermethrin remains viable under strict monitoring to prevent future resistance. This study underscores the need for targeted insecticide use and regular monitoring to optimize vector control strategies and minimize DHF transmission

Introduction

The incidence of Dengue Hemorrhagic Fever (DHF) continues to rise, especially in urban and semi-urban regions, establishing it as a significant global public health concern (Frank *et al*., 2024; Lorenz *et al*., 2020; Yang *et al*., 2021). Dengue fever is a viral infection caused by the dengue virus and transmitted through mosquito bites (Paz-Bailey *et al*., 2024). *Aedes (Ae.) aegypti* and *Ae. albopictus* are vectors of dengue fever. Morphologically, the two are very similar but can be distinguished by their morphology, especially in the dorsal thorax, called the scutum. The scutum of *Ae. aegypti* is black with two parallel white stripes in the middle of the dorsal side, flanked by two curved white lines (Azari-Hamidian *et al*., 2024; Yamany *et al*., 2024; Yamany & Abdel-Gaber, 2024). *Ae. albopictus* mosquitoes are more commonly found outdoors, in gardens, and in bushes, while *Ae. aegypti* prefers indoor habitats, often resting on hanging clothes (Seang-arwut *et al*., 2023; Supriyono *et al*., 2023)

The *Ae. aegypti* mosquito, as the primary vector for dengue fever, is largely attributed to its preference for blood feeding on humans indoors and its selective breeding habits (Bursali & Simsek, 2024; Facchinelli *et al*., 2023). *Ae. aegypti* tends to lay eggs in indoor water-holding containers, such as water buckets, flower vases, or unclean bathtubs.

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pISSN 1858-1196
eISSN 2355-3596

Research by (Dalpadado *et al*., 2022; Mbanzulu *et al*., 2022) indicates that the mosquito's breeding preferences are heavily influenced by the availability of stagnant clean water, which provides an ideal environment for eggs and larvae to develop. If individuals fail to recognize the importance of maintaining cleanliness and monitoring such sites, the potential for increased cases of diseases transmitted by *Ae. aegypti* will rise. Therefore, preventive efforts through regular monitoring of mosquito breeding sites are crucial to reducing the risk of disease transmission (Kolimenakis *et al*., 2021).

Mapping the breeding sites of *Ae. aegypti* mosquitoes can be an effective vector control strategy to reduce dengue fever cases. Preventive efforts also include mosquito breeding site eradication through the program covering, draining, and burying promoted by government (Puluhulawa *et al*., 2023), and the use of chemical insecticides, which are considered more efficient in quickly killing mosquitoes. These efforts will be effective as long as the targeted mosquitoes have not developed resistance to the insecticides being used (Namias *et al*., 2021). The emergence of resistant insects was first reported in 1914 with *Quadraspidiotus pernicious*. Since the first mosquito resistance case was reported in 1947, over a hundred mosquito species have become resistant to one or more insecticides. The development of resistant mosquito strains is triggered by prolonged and ineffective exposure to chemical substances (Dahmana & Mediannikov, 2020). Resistance occurs when mosquitoes develop immune systems capable of countering frequently used insecticides (Suh *et al*., 2023). Studies also highlight the occurrence of cross-resistance, where resistance to one insecticide arises due to exposure to another (Moyes *et al*., 2021). Insecticide sources—such as agriculture, households, industries, healthcare, and others may all contribute to the emergence of resistance (Okeke *et al*., 2022).

Community behavior also plays a significant role in the emergence of resistant species, particularly with the frequent use of spray insecticides. Various types of insecticides are available in Indonesia, such as Malathion, Chlorpyrifos, Cypermethrin, Permethrin, Carbaryl, and acetamiprid. Moreover, 0.8% Malathion and 0.05% Cypermethrin insecticides are the most used in Indonesia (Silalahi *et al*., 2022). Vector control efforts with insecticides are effective only if the targeted mosquitoes have not developed resistance to the insecticides. Research on breeding site preferences and the resistance status of *Ae. aegypti* mosquitoes to Cypermethrin and Malathion has not been conducted in Malang city, Indonesia, making this study crucial for providing recommendations to the government on appropriate insecticide usage. This study aimed to assess the breeding preferences of *Ae. aegypti* in Malang City and evaluate their resistance to 0.8% Malathion and 0.05% Cypermethrin.

Methods

This study uses a descriptive observational research design. The sampling technique used was simple random sampling. The samples consist of *Ae. aegypti* eggs and larvae obtained using ovitraps, distributed in three districts within Malang City, and for the preference of breeding sites, a citizen science based on the interview was used. *Ae. aegypti* eggs were hatched in plastic trays containing ±1000cc of clean water. The larvae that hatch are fed pellets daily. The larvae are maintained until they reach the third instar stage, approximately 2-3 days, after which the fourth instar larvae (pupae) are transferred to trays containing water inside mosquito cages, so that when the pupae transform into mosquitoes, they will be inside the cage (Permana *et al*., 2024). The next step is to acclimatize the mosquitoes until they are 3-7 days old, providing them with a 10% sugar solution as food (Nuryady *et al*., 2024).

In the resistance test, mosquitoes are divided into four tubes, each containing 20-25 female *Ae. aegypti* mosquitoes that are well-fed with sugar and 3-7 days old. The four tubes consist of three replicate tubes containing 0.8% Malathion insecticide and one control tube. The same procedure is performed for the 0.05% Cypermethrin treatment. The mosquitoes are exposed to the insecticide for 60 minutes (with mortality observations at 15, 30, 45, and 60 minutes). After being exposed, the mosquitoes are transferred to holding tubes without insecticide, left for 24 hours in a room

with a room temperature around 22°C-25°C, and provided with a 10% glucose solution as food. Subsequently, an analysis is performed by counting the mosquito mortality and interpreting the results according to the WHO guidelines. Observations are made by counting the mosquito mortality and interpreting it according to the WHO guidelines. The criteria are: mortality <80% is resistant, mortality 80-98% is tolerant, and mortality 99-100% is susceptible. Testing must be repeated if mortality in the control group exceeds 20%. The mortality rate of the test mosquitoes is corrected using Abbott's formula (Qibtiyah *et al*., 2022).

Result and Discussion

Malang City is known for its high incidence of dengue fever (Dengue Hemorrhagic Fever, DBD), with a mortality rate reaching 0.80% over the past decade. One of the factors that correlated with the high incidence of dengue fever is the abundance of the vectors, *Ae. aegypti* (Horta *et al*., 2014). Based on the results of monitoring the breeding site preferences of *Ae. aegypti* mosquitoes in Malang City, bathroom water tanks are the most common places where *Ae. aegypti* larvae are found (Figure 1).

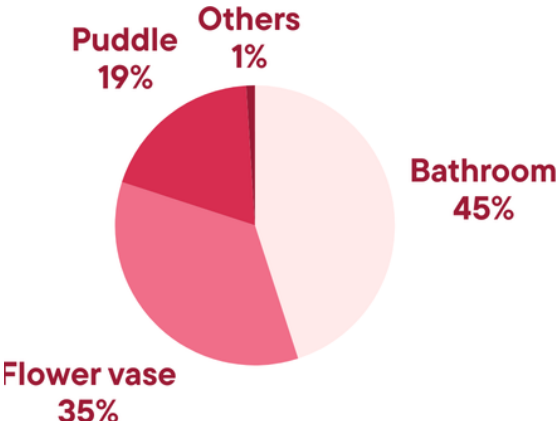

FIGURE 1. Breeding Site Percentage of *Ae. aegypti* in Malang City

The figure illustrates the distribution of *Ae.aegypti* breeding sites, highlighting that bathrooms account for the largest proportion (45%), followed by flower vases (35%), puddles (19%), and other sources (1%). This data aligns with recent research findings emphasizing that the bathroom water tank is a suitable breeding site for mosquitoes. Most bathroom water tanks in Indonesia are made of concrete, which presents a significant potential breeding site for Aedes mosquitoes due to their larger volume (Nurjana & Kurniawan, 2017; Simatupang & Wicharana, 2021). Additionally, these bathroom tanks are rarely cleaned at least once a week, and many are also less exposed to direct sunlight (Prasetyowati *et al*., 2018). Furthermore, Malang City is also known as an educational hub, with numerous public and private universities, which are attracting a large number of students, and this is accompanied by an increasing number of boarding houses for students. A survey on the breeding sites of *Ae. aegypti* mosquitoes show that bathroom water tanks are still related to the environmental factors found in many boarding houses. The hygiene of boarding houses is generally lower compared to private residences, which results in the highest number of mosquito larvae being found in bathroom water tanks (Agus Nurjana *et al*., 2023). Besides, flower vases also had a fairly high number of breeding preferences due to the stagnant water in these vases which provides an ideal breeding environment. The water is often not disturbed or changed frequently, creating a perfect habitat for mosquito larvae to thrive, especially in shaded or enclosed areas that limit sunlight exposure and reduce evaporation (Herath *et al*., 2024). These results show that upcoming plans to control mosquito breeding should focus not only on making the environment cleaner but also on changing the habits of people who live or stay temporarily, like students or those who run boarding houses.

While identifying breeding sites provides an essential foundation for environmentally-based interventions, vector control efforts also rely heavily on the use of insecticides (Chahaya *et al*., 2024). The success of such chemical control measures, however, depends greatly on the susceptibility of mosquitoes to the compounds being applied (Versari *et al*., 2021). Therefore, the following section of this study assesses the resistance status of *Ae. aegypti* populations in three districts of Malang City to two commonly used insecticides: 0.05% cypermethrin and 0.8% malathion. To support this, ovitrap

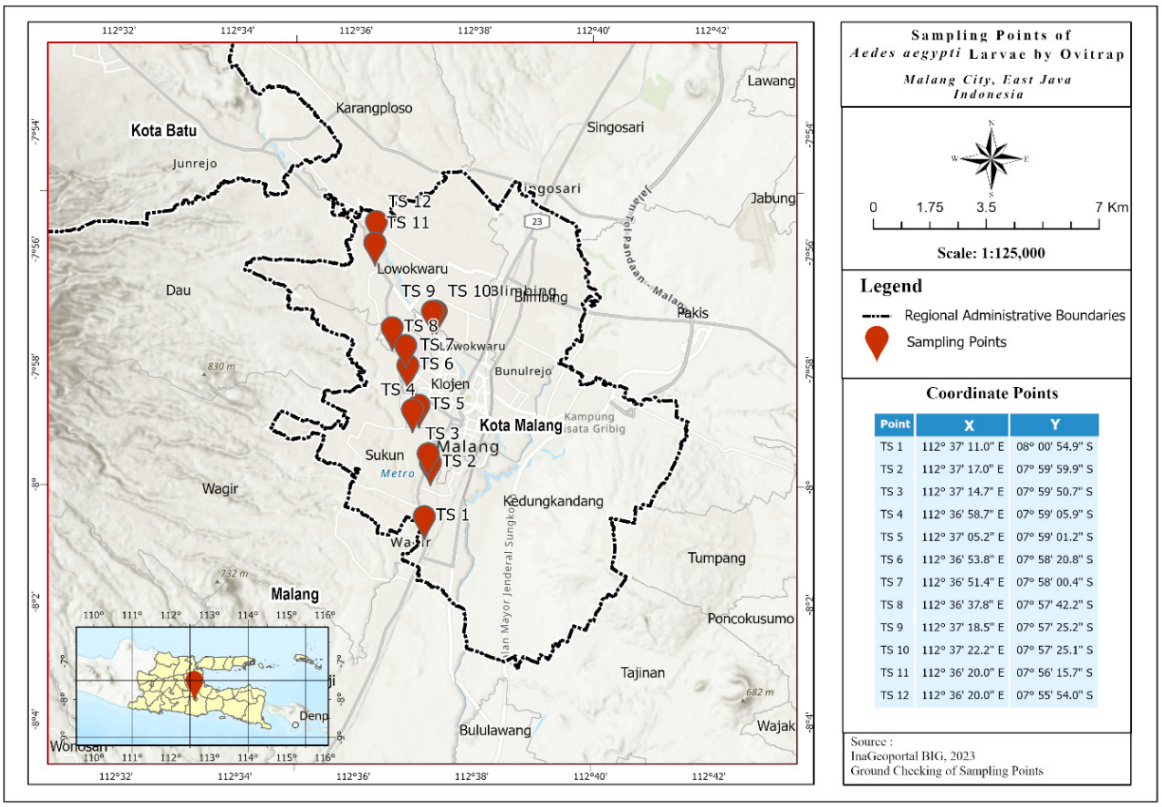

FIGURE 2. Sampling Point of Egg and Larvae of *Ae. aegypti* by Using Ovitrap

sampling was conducted in selected locations based on dengue fever case data, enabling a spatially informed evaluation of both breeding site prevalence and insecticide resistance levels. The distribution of ovitraps sampling for *Ae. aegypti* larvae and eggs were carried out based on dengue fever (DF) case data from the Health Department of Malang (Dinkes, 2019), which consists of three districts. The sampling points in each district varied, with a minimum of three sampling points in each district (Figure 2).

The result of resistance tests for *Ae. aegypti* to Cypermethrin 0.05% (Table 1) revealed differing susceptibilities across districts. In District 1, the mortality rate consistently ranged between 78% and 82%, classifying the population as resistant. In contrast, mosquitoes from Districts 2 and 3 achieved 100% mortality in all repetitions, indicating full susceptibility to the insecticide. This geographical variability might show that different areas have different amounts of fogging, different levels of city buildings, and different ways people use insecticides at home. District 1 is a place with more people and more businesses, so it might have more pressure on insects because people there use insecticides more often at home.

For 0.8% Malathion, the susceptibility results varied more significantly. In District 1, mosquitoes exhibited high mortality rates (94-100%), categorizing them as either susceptible or possibly resistant. In District 2, a similar trend was observed, with a mortality range from 94% to 100%. However, in District 3, the mortality rates were substantially lower (33-53%), confirming resistance. It indicates a concerning level of Malathion resistance in District 3, underscoring the potential need to reconsider its usage in this region (Table 2).

The resistance test results indicate that *Aedes aegypti* in Malang City exhibits a tolerant status to 0.05% cypermethrin. This finding aligns with several previous studies reporting similar outcomes in various regions of Indonesia, including Banyumas, West Lombok, Pekanbaru, Batam, Yogyakarta, and Bitung, where Aedes spp. populations were also categorized as tolerant to cypermethrin

TABLE 1. Resistance Test Results of *Ae. aegypti* Susceptibility to 0.05% Cypermethrin

Testing	Sample (n)	Time (hour)	District 1		District 2		District 3	
			% Death mosquito	Status	% Death mosquito	Status	% Death mosquito	Status
Control	23	1	4		8		0	
Repetition 1	23	1	78	Resistance	100	Susceptible	100	Susceptible
Repetition 2	23	1	82	Resistance	100	Susceptible	100	Susceptible
Repetition 3	23	1	82	Resistance	100	Susceptible	100	Susceptible

*Average mortality 93,6% indicate Tolerant

TABLE 2. Resistance Test Results of *Aedes aegypti* Susceptibility to Malathion 0.8%

Testing	Sample (n)	Time (hour)	District 1		District 2		District 3	
			% Death mosquito	Status	% Death mosquito	Status	% Death mosquito	Status
Control	15	1	0		0		0	
Repetition 1	15	1	100	Susceptible	94	Tolerant	53	Resistance
Repetition 2	15	1	94	Tolerant	100	Susceptible	33	Resistance
Repetition 3	15	1	94	Tolerant	100	Susceptible	40	Resistance

*Average mortality 78,7% indicate Resistance

(Adrianti *et al*., 2024; Handayani, 2023). Meanwhile, the average mortality rate for *Aedes aegypti* exposed to 0.8% malathion was 78.7%, which classifies *Ae. aegypti* in Malang City is resistant to malathion, based on WHO criteria. However, this result is primarily driven by the significantly lower susceptibility observed in District 3, while populations in Districts 1 and 2 remained within the tolerant or susceptible range. It highlights a potential localized resistance in District 3, which substantially influences the overall resistance status. This finding is consistent with previous studies conducted in North Toraja, West Lombok, Magetan, and Jakarta, which also reported malathion resistance among *Ae. aegypti* populations (Ishak & Ponno, 2018; Triana *et al*., 2020).

These resistance patterns should not be interpreted in isolation from ecological behaviors that contribute to their development. One of the key factors influencing the persistence of resistant mosquito populations is the location and nature of their breeding habitats (Herath *et al*., 2024). The observed breeding site preferences, predominantly bathroom water tanks and flower vases, indicate a strong tendency of *Ae. aegypti* to utilize indoor habitats for reproduction. These sites are largely protected from external insecticidal interventions such as fogging, which commonly targets outdoor environments. This ecological behavior may reduce the overall effectiveness of fogging programs and, more importantly, create microenvironments where mosquitoes can survive repeated public health interventions (Lee *et al*., 2020).

However, the variation in insecticide resistance across districts may still be partially explained by the patterns of fogging activity and the types of insecticides used (Dusfour *et al*., 2019). In Indonesia, malathion has been the standard compound for fogging operations for decades, including in Malang (Silalahi *et al*., 2022). It is plausible that District 3, which exhibited the highest level of malathion resistance, has experienced more frequent malathion-based fogging due to higher dengue case reports. Despite the indoor breeding tendencies, adult mosquitoes—once emerged—may still be exposed to fogging if they rest near entryways, windows, or semi-outdoor spaces. Repeated malathion exposure in such scenarios could drive resistance accumulation in that area (Silalahi *et al*., 2024).

In contrast, resistance to cypermethrin was only observed in District 1. This area is known to have higher population density and commercial activity, which may increase the frequency of household insecticide use, including over-the-counter sprays that often contain pyrethroids like cypermethrin. Such

unsupervised use can contribute to sublethal exposures, promoting tolerance or resistance. The cumulative effect of breeding in protected indoor containers and inconsistent insecticide exposure—whether via fogging or household use—creates a complex ecological and chemical landscape that fosters resistance in specific zones, despite uniform breeding preferences across the city (Guedes *et al*., 2017).

Insecticide resistance in Aedes mosquitoes, particularly *Aedes aegypti*, is predominantly driven by an interplay of target-site mutations and metabolic detoxification mechanisms. Knockdown resistance (*kdr*) mutations within the voltage-gated sodium channel gene, especially V1016I, F1534C, and V410L (Barrera Illanes *et al*., 2022; Pareja-Loaiza *et al*., 2020). These mutations often co-occur and form tri-locus haplotypes that confer additive or even synergistic resistance effects, with their increasing frequencies documented across diverse geographic regions including the Americas, Africa, and Asia (Akhir *et al*., 2022). Concurrently, metabolic resistance mechanisms, primarily mediated through overexpression and gene amplification of cytochrome P450 monooxygenases, glutathione S-transferases, and esterases, significantly contribute to resistance, particularly against organophosphates such as malathion (Soumalia Issa *et al*., 2024). This metabolic resistance often coexists with target-site mutations, suggesting a multifactorial resistance architecture wherein both mechanisms are essential to fully explain phenotypic resistance.

Moreover, the possibility of cross-resistance between insecticide classes cannot be ruled out. Long-term use of a single insecticide class may select for generalist resistance mechanisms, reducing susceptibility across multiple compounds. It is particularly concerning given the reliance on both malathion and cypermethrin in local vector control programs (Bass & Nauen, 2023).

From a public health policy perspective, these findings emphasize the urgent need for integrated vector management strategies. It is crucial to promote routine insecticide resistance surveillance, diversify the types of insecticides used, and rotate chemical classes to prevent the buildup of resistance (Cahyati & Siyam, 2019). Additionally, public education on proper insecticide use and environmental management should be strengthened, particularly in high-risk zones like Districts 1 and 3. In the long term, establishing entomological surveillance systems that include molecular diagnostics for resistance markers can help authorities track the evolution of resistance and respond with timely interventions. Combining these efforts with behavioral change campaigns targeting breeding site reduction will offer a more sustainable and resilient approach to dengue vector control in Malang City.

Conclusion

This study highlights that *Ae. aegypti* in Malang City primarily breed in bathroom water tanks and flower vases, indicating the need to target these sites in control efforts. Resistance to 0.8% malathion is widespread, especially in District 3, making its use for vector control ineffective. Conversely, 0.05% cypermethrin remains effective in most areas but requires strict monitoring to prevent resistance. These findings emphasize the importance of region-specific vector control strategies and the rotation of insecticides to maintain their efficacy and reduce the risk of resistance development.

Acknowledgement

The author would like to express his gratitude to DPPM UMM and FK UM for providing this research grant. Furthermore, special thanks to Dr. rer.nat. Hans-peter Fuehrer for supervising and guiding the authors.

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KEMAS 21 (2) (2025) 290-300

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Vitamin D and Lifestyle Factors in Active Smoker in Indonesia

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Article Info

Article History:
Submitted: March 2025
Accepted: September 2025
Published: October 2025

Keywords:
vitamin D;
lifestyle factors; smoker

DOI
https://doi.org/10.15294/kemas.v21i2.22618

Abstract

Smoking can affect vitamin D levels in the blood. Decrease in vitamin D levels is also influenced by a person's lifestyle habits, such as smoking habits, sun exposure, food intake, and physical activity. This study aimed to determine the relationship between vitamin D and lifestyle factors in active smokers. This research used a cross-sectional design. The subjects were adult male active smokers in Rungkut Subdistrict, Surabaya City, from October 2023 to February 2024. The sampling method was a purposive sampling technique. Data collection by measurement of smoking severity (Brinkman Index (BI)), vitamin D levels in blood (serum 25(OH)D), food intake (by SQ-FFQ (semi-quantitative food frequency questionnaire) and 24-hour food recall), and physical activity (by IPAQ (International Physical Activity Questionnaire)). The relationship is measured using the Spearman method (ordinal scale). There were 47 respondents. The majority of research respondents were moderate smokers, namely 38 people (80.85%). The respondents had an average 25(OH)D level of 23.19±8.86 ng/mL. The risk of vitamin D deficiency due to lack of sun exposure was 26 people (55.32%). The average consumption of foods containing vitamin D by SQ-FFQ was 5.75±5.68 mcg/day, and 24-hour food recall was 5.77±5.72 mcg/day. Most respondents had high physical activity (70.21%), and the total mean was 8210.23±4955.89. The Spearman correlation coefficient was 0.742 (smoking severity), 0.117 (sun exposure), 0.726 (food intake by FFQ), 0.742 (food intake by 24-hour recall), and 0.824 (physical activity). Vitamin D levels had a significant association with the severity of smoking, food intake, and physical activity. However, they were not related to sun exposure.

Introduction

Smoking is responsible for a high proportion of morbidity and mortality in Indonesia (Holipah *et al*., 2020). Based on Global Adult Tobacco Survey (GATS) data in 2021, the number of smokers in Indonesia increased by 8.8 million people from 2011, namely 60.3 million to 69.1 million people smoked, and 65.5% of them are male smokers (GATS, 2021). The prognosis for these health problems is worsened by the fact that smoking can cause vitamin D deficiency (Yang *et al*., 2021; Yang *et al*., 2022), and this vitamin D deficiency has an impact on various diseases (Amrein *et al*., 2020). A meta-analysis study, which included 24 studies and involved 11,340, showed that 25(OH)D levels in smokers were lower than in non-smokers (Yang *et al*., 2021). Sources of vitamin D come from food and exposure to sunlight (Suryadinata *et al*., 2021). The primary causes of vitamin D deficiency are decreased skin synthesis due to low sunlight exposure, age, certain drugs that can reduce vitamin D levels, and obesity (Lorensia *et al*., 2022). Data on the prevalence of vitamin D deficiency in various European, American, and Asian countries varies widely, from 42% to 90%. A study in Indonesia showed that

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pISSN 1858-1196
eISSN 2355-3596

50% of women aged 45-55 years had vitamin D deficiency. In addition, there was another study in Jakarta and Bekasi, which stated that 74 female subjects aged 60-75 years had a fairly high vitamin D deficiency, namely 35 .1%. The results of collaborative research between Malaysia and Indonesia, conducted in Kuala Lumpur and Jakarta, also found that the subjects had an average serum 25(OH)D concentration of 48nmol/L. Based on several studies presented, it can be concluded that people living in tropical countries are not fully guaranteed a vitamin D status (Rimahardika *et al*., 2019).

Smoking can affect vitamin D levels in the body in many ways, including affecting vitamin D intake, synthesis, hydroxylation, and catabolism of vitamin D (Mousavi *et al*., 2019). When someone inhales cigarette smoke, as many as 4000 chemicals are inhaled and enter the lungs, especially nicotine (Pemerintah Republik Indonesia, 2012). The potential effects on the central nervous system (CNS) regulation of nicotine can also influence appetite, distracting from the perception of hunger or the desire to consume food and energy expenditure. This decrease in appetite in smokers can cause a decrease in food intake containing vitamin D, which can result in vitamin D deficiency (Wu *et al*., 2021). In Indonesia, previous research by Lorensia *et al*. (2024) involved 144 subjects, consisting of 73 non-smokers and 71 smokers. The smokers' group had a 2,553 times higher risk of vitamin D deficiency than non-smokers.

Vitamin D is a fat-soluble vitamin found in food and can also be produced in the body after exposure to sunlight. Sources of vitamin D can come from animal foods, namely fatty fish, tuna, milk, egg yolks, seafood, and foods derived from plants, like mushrooms (Dominguez *et al*., 2021). According to the 2019 Regulation of the Minister of Health of the Republic of Indonesia, the Nutritional Adequacy Rate (AKG), recommended vitamin D intake is 15 mcg/day (Kementrian kesehatan. Peraturan Mentri Kesehatan Republik Indonesia Nomor 28 Tahun 2019, 2019). The first process of vitamin D is in the liver into the prehormone 25-hydroxycholecalciferol or 25(OH)D. Vitamin D deficiency is defined as 25(OH)D levels <20 ng/mL (Amrein *et al*., 2020; Mustafa and Shekhar, 2021). Awareness of the importance of consuming foods containing vitamin D must be implemented from an early age to prevent vitamin D deficiency, especially in the smoking population, where nicotine in cigarette smoke can reduce the intake of foods containing vitamin D (Yang *et al*., 2022). The more frequently you consume cigarettes, the more nicotine content enters the CNS, and the more it will reduce an individual's food intake (Menshov *et al*., 2022).

Dietary intake affects individual health (Zhou *et al*., 2023). Assessment of the adequacy of an individual's intake of food containing vitamin D needs to be carried out for early action to prevent vitamin D deficiency. This assessment can employ a dietary evaluation to assess the intake of food containing vitamin D consumed by the individual, using the semi-digestive method. -quantitative Food Frequency Questionnaire (SQ-FFQ) and 24-hour Food Recall. Semi-quantitative FFQ will assess respondents' eating patterns retrospectively within the last month. The 24-hour Food Recall is also a method of dietary assessment, retrospectively. It provides information about the food and drinks consumed by respondents in the last 24 hours (Watkins *et al*., 2021; Moridpour *et al*., 2022). The combination of FFQ and 24-hour Food Recall improves the correlation with actual intake to predict individual diet, so that it can be correlated with individual health conditions (Kostaras *et al*., 2021).

Vitamin D is linked to physical activity; indoor physical activity is associated with increased vitamin D levels (Al-Daghri *et al*., 2023). There is an increase in plasma vitamin D concentrations with both indoor and outdoor physical activity. Smokers who had intense physical activity had the strongest positive relationship with vitamin D levels. Measurement of physical activity uses a questionnaire, namely the International Physical Activity Questionnaire (IPAQ). The IPAQ is an instrument developed to establish a standardized and culturally adaptable measurement tool to measure physical activity in different cultural regions of the world (Andriyani *et al*., 2020; Anindya *et al*., 2022). All values are expressed in MET- minutes/

week. Metabolic Equivalents (METs) are used to express the intensity of physical activity. Metabolic Equivalent of Task (MET) is the ratio of a person's average working metabolic rate to their resting metabolic rate (Chandrashekar *et al*., 2019). This study aimed to determine the relationship between vitamin D and the severity of smoking, sun exposure, food intake containing vitamin D, and physical activity.

Method

This research uses a cross-sectional design. It took place in Rungkut Village, Surabaya City, considering that it had met the inclusion criteria. This research took time from October 2023 to February 2024. The variables in this study consist of the independent variable, namely vitamin D levels, and the dependent variables consist of: smoking level, sun exposure, food intake containing vitamin D, and physical activity. An active smoker is someone who consumes cigarettes regularly, no matter how small, even if only 1 (one) cigarette a day (Hackshaw *et al*., 2018). Smoking activity is the activity of burning tobacco and then inhaling the smoke, either using a cigarette or using a pipe (Sutfin *et al*., 20221). Smoking activity in this study was measured from two indicators, namely smoking frequency and cigarette type.

The population in this study was adult male active smokers in Rungkut Subdistrict, Surabaya City. The sample in this study was taken from part of the population that met the criteria, including respondents in the category of teenagers to adults with an age range of 19 years and over, and who were willing to participate in the research. The number of adult males in Rungkut sub-district was 125, and there were 51 people who had the status of active adult smokers. To calculate the minimum number of samples needed, a calculation is required using the Slovin formula. N=Total Population (51 respondents who are active adult smokers) e=Desired critical value (accuracy limit) (percentage of tolerance for inaccuracy due to sampling error) (5%). Based on the results of these calculations, the minimum sample size in this study is at least 46 respondents. The sampling method used in this research is a purposive sampling technique.

Smoking frequency was obtained from respondent interviews regarding the number of cigarettes smoked per day and the length of smoking (years). Brinkman Index (IB) = number of cigarettes smoked per day x smoking length (years). The Brinkman Index has been standardly used in Indonesia to determine a person's smoking frequency/degree. The results of IB are classified into 3, namely: mild (0-200), moderate (201-600), and severe (>600) (Herath *et al*., 2022; Onishi *et al*., 2022). Then, measurement of Vitamin D (25(OH)D) levels in human serum uses VIDAS® 25 OH Vitamin D TOTAL (VIT D), which is an automatic quantitative test by the ELFA (Enzyme Linked Fluorescent Assay) technique. VIDAS® 25 OH Vitamin D TOTAL will be used as an aid in the assessment of Vitamin D adequacy. Serum 25(OH)D levels can be classified into several categories, namely: deficiency (<20 ng/mL), insufficiency (20-29 ng/mL), sufficient (20-29 ng/mL), and potential toxicity (>100 ng /mL) (Mustafa and Shekhar, 2021).

The main components in this questionnaire are a list of foods, the frequency of foods at certain times, and the portions of food consumed. Interviews were conducted with the help of a food photo book published by the Indonesian Ministry of Health in 2014 (Benedik, 2022) to make it easier to measure the URT portion of food consumed by respondents. Calculation of vitamin D nutrition in the food consumed by respondents is carried out by recording the type and amount of food consumed during the previous 24 hours using the URT tool, then the data will be converted from URT into weight (grams), using the nutrisurvey application and then in the total amount of vitamin D intake from the entire list of foods consumed by respondents and matched with the Recommended Nutritional Adequacy List (DKGA) in Indonesia (Watkins *et al*., 2021; Moridpour *et al*., 2022; Kostaras *et al*., 2021). This research does not carry out validity because it has been carried out in previous research by Suryadinata *et al*. (2019) and Lorensia *et al*. (2019). The method for measuring physical activity uses the IPAQ (International Physical Activity Questionnaire) questionnaire. The data scale obtained from the measurement of physical activity was an

ordinal data scale, where the results obtained from the patient questionnaire were categorized into low, medium, and high physical activity (Lorensia *et al*., 2022; Sember *et al*., 2020). The collected data will be compiled and analyzed to determine the factors that influence 25-hydroxycholecalciferol (25(OH)D) levels through the intake of foods containing vitamin D in active smoker respondents. The method used in this research is an ordinal data scale. Ordinal data scale using the Spearman test.

Result and Discussion

The research took place in Rungkut District, Surabaya City, from October 2023 to February 2024, after obtaining ethical clearance from the University of Surabaya Ethics Committee with the number: 236/KE/IX/2023. The preliminary study regarding the number of active smokers by distributing questionnaires identified 79 residents as active smokers. However, during the meeting at the community head's activity with residents, which had been previously designed with researchers, only 51 active smoking residents were present. After explaining the research and taking measurements from respondents, four people were excluded from the research due to exclusion criteria, including two vegetarians and two obese people who had a BMI >27 kg/m^2, so the final number obtained was 47 respondents.

The average age of research respondents was 51±6.43 years, which fell into the middle-aged category, namely around 46 people (97.87%). Based on the latest educational data, most respondents were high school graduates, namely 21 people (44.68%). Most respondents had a normal BMI, namely 26 (55.32%) respondents, and the average BMI value of research respondents was 24.13±1.95 kg/m^2. Data on the smoking activity of respondents in this study have been obtained. Smoking activity data in this study were assessed using two assessment indicators, namely smoking frequency and type of cigarette used. Based on smoking frequency data in Table 4.1, the majority of research respondents were moderate smokers, namely 38 people (80.85%) (**Table 1**).

Measurement of Vitamin D (25(OH)D)

Table 1. Characteristics Profile of Research Respondents

Respondent Characteristics		Category	Frequency (n=47)	Percentage (%)
Demographics	Age (Years)	Adulthood (18-39)	1	2.13
		Middle-aged youth (40-60)	46	97.87
	Education Level	No school	1	2.13
		Elementary school	8	17.02
		Junior high school	9	19.15
		Senior high school	21	44.68
		Bachelor's degree	8	17.02
Anthropometrics	BMI (kg/m^2) (Khanna et al., 2022)	Normal (18.5-25)	26	55.32
		Overweight (25.1-27)	21	44.68
Smoking Activities	Index Brinkman (Herath et al., 2022; Onishi et al., 2022)	Mild Smoker (IB <200)	9	19.15
		Moderate Smoker (IB 201-600)	38	80.85

Source: Primary Data, 2024

Table 2. Profile of Research Respondents Based on Results of 25(OH)D Levels

Categories of 25(OH)D level (ng/mL)*	Frequency (n=47)	Percentage (%)	x ± SD (ng/mL)
Deficiency (<20)	15	32	23.19 ± 8.86
Insufficiency (20-29)	23	49	
Enough (30-100)	9	19	

* Serum 25(OH)D Level Examination Results from a Standardized Laboratory (Lorensia *et al*., 2024; Mustafa and Shekhar, 2021; Georgakopaulou *et al*., 2020)

Source: Primary Data, 2024

Table 3. Sun Exposure Profile of Respondents

No.	Questions	Answers	Frequency (n= 47)	Percentage (%)
1.	What time do you usually get direct sunlight?	07.00-09.00	26	55.32
		10.00-11.00	12	25.53
		12.00-14.00	7	14.89
		15.00-17.00	2	4.26
2.	Do you use skin protection equipment (umbrella, hat, jacket, sunscreen cream, etc.) from direct exposure to sunlight direct?	Yes	44	93.62
		No	3	6.38
3.	What skin protective equipment do you use **(There can be more than one answer)**	Umbrella	2	4.26
		Hat	29	61.70
		Jacket	26	55.32
		Sun block/sunblock	3	6.38
		Other	2	4.26
4.	How often do you use skin protection equipment in question **no.3** ?	Everyday	7	14.89
		Sometimes	26	55.32
		Seldom	11	23.40
		Never	3	6.38
5.	Do you usually wear closed clothes, such as long-sleeved shirts and long trousers? day ?	Yes	32	68.09
		No	15	31.91
6.	Which parts of the body do you want to protect from direct sunlight with the protective equipment you chose in question **no. 3** ? **(there can be more than one answer)**	Face	26	55.32
		Hand	7	14.89
		Arm	9	19.15
		Foot	2	4.26
		Back and shoulders	19	40.43
		Whole body	6	12.77
		Never	3	6.38
7.	Do you use cosmetic products (facial moisturizer, cream and body *(body cream)* , powder etc with SPF content?	Yes	5	10.64
		No	42	89.36
8.	Does the cosmetics you use contain protection from UVA and UVB?	Yes	2	4.26
		No	45	95.74
	Classification of risk of deficiency due to lack of sun exposure		**Frequency (n= 47)**	**Percentage (%)**
	Has a risk of deficiency due to lack of sun exposure		26	55.32
	Has no risk of deficiency due to lack of sun exposure		21	44.68

Source: Primary Data, 2024

level of 23.19±8.86 ng/mL. There were only 9 respondents who had sufficient 25(OH)D levels (19%), then 23 people (49%) fell into the Insufficiency category, and 15 people (32%) had vitamin D deficiency (**Table 2**).

Frequency and percentage results of exposure to sun in active smokers show that in the group at risk of vitamin D deficiency due

levels in the serum of research respondents was carried out by a standardized laboratory, using VIDAS® 25 OH Vitamin D TOTAL (VIT D), which is an automatic quantitative test using the ELFA (Enzyme Linked Fluorescent Assay) technique. The results of serum 25(OH)D levels were grouped into three based on the VIDAS® 25 OH Vitamin D TOTAL reference range. The results of grouping respondents showed that respondents had an average 25(OH)D

Table 4. Results of Food Intake Containing Vitamin D for Research Respondents

Food Intake Method	Results of Intake of Foods Containing Vitamin D (mcg/day) (Benedik, 2022)	Category	Frequency (n=47)	Percentage (%)	x ± SD (mcg/day)
SQ-FFQ	>15	Enough	10	21.28	5.75 ± 5.68
	<15	Not enough	37	78.72	
24-hour Food Recall	>15	Enough	9	19.15	5.77 ± 5.72
	<15	Not enough	38	80.85	

Source: Primary Data, 2024

Table 5. Profile Distribution Frequency Activity Physique Respondent

Respondent		Frequency (n: 47)	Percentage (%)	Average	Average total	SD
Category Activity Physique (MET-min/week) (Lorensia et al., 2022; Sember et al., 2020)	Low	7	14.89	340.9	8,210.23	4955.89
	Moderate	7	14.89	1064.1		
	High	33	70.21	6805.23		

Source: Primary Data, 2024

Table 6. Spearman Correlation Analysis between the Serum 25(OH) Vitamin D and Lifestyle Factors

Lifestyle Factors	R	P value
Smoking severity	0.742*	0.000
Sun exposure	0.117	0.624
Food intake by FFQ	0.726*	0.000
Food intake by recall 24 hours	0.742*	0.000
Physical activity	0.824*	0.000

R = Spearman rho.
*Correlation is significant at the 0.01 level (2-tailed)
Source: Primary Data, 2024

to lack of sun exposure, namely, as many as 26 people (55.32 %), and those who did not have a risk were as many as 21 people (44.68%). The respondent's answer profile can be seen in **Table 3**.

Data on food intake containing vitamin D from research respondents was obtained using two methods of measuring food intake, namely the semi-quantitative food frequency questionnaire (SQ-FFQ) and 24-hour food recall. SQ-FFQ measures respondents' food intake over the past month which was collected using the SQ-FFQ questionnaire containing a list of 11 foods that contain vitamin D, by adding fortified products such as milk with a vitamin D content of 7.5 mcg/35g, milk with a vitamin D content of 2.5 mcg/32g and eliminating shiitake mushrooms and button mushrooms because based on preliminary studies, no community around the research location consumed these foods. Milkfish has the highest vitamin D content. Every 100 g of milkfish contains 10 mcg of vitamin D; however, in the SQ-FFQ results, respondents only consumed an average of 7.59g of milkfish, which contained 0.8 mcg of vitamin D/day. The vitamin D content in fortified products such as milk used by respondents in this study is that every 35g of milk contains 7.5 mcg of vitamin D. Respondents consumed milk with a vitamin D content of 7 mcg/35g of 10.53g with a vitamin D result of 2.3 mcg/day, while the least is tilapia fish, namely every 40g of tilapia fish contains 0.4 mcg of vitamin D (**Table 4**). The average consumption of foods containing vitamin D in research respondents was 5.75 ± 5.68 mcg/day. Only 10 respondents

(21.28%) could meet the daily RDA for vitamin D; the other 37 respondents (78.72%) did not meet the RDA for vitamin D (**Table 4**).

The average 24-hour food recall results show that the foods containing vitamin D that respondents consumed most were eggs (37.66g), then pindang fish (10.21g), milk with a Vitamin D content of 7 mcg/35g (9.93g), while the least consumed was anchovies (0.89g). The results of the interview regarding food intake containing vitamin D were obtained using a food recall, and the vitamin D value per person per day was obtained using the Nutrisurvey application. On average, food products that have the highest vitamin D value are milk with a Vitamin D content of 7 mcg/35g (2.1 mcg), catfish (0.7 mcg), milkfish (0.7 mcg), pindang fish (0.6 mcg), and the food with the least vitamin D value is tilapia fish (0 mcg) (**Table 4**).

The average results of food intake containing vitamin D from the Nutrisurvey application for all research respondents (47 respondents), namely the 1st recall which was carried out on weekdays, resulted in an average intake of vitamin D of 5.0 ± 6.7 mcg/day, recall The second recall which was also carried out on weekdays resulted in an average vitamin D intake of 5.5 ± 6.2 mcg/day and the third recall which was carried out on holidays resulted in an average vitamin D intake of 6.9 ± 6 .6 mcg/day mcg/day. It is in accordance with existing theory, which states that the effect of holidays can provide a different picture of intake because food intake on holidays is usually greater than on weekdays. The average intake of foods containing vitamin D consumed by respondents was 5.77±5.72 mcg/day. Table 4 shows that only 9 people (19.15%) were said to consume enough foods containing vitamin D according to the AKG recommendations, and 38 people (80.85%) did not meet the AKG recommendations for vitamin D. Based on **Table 5**, 45 respondents with high physical activities had the largest percentage, namely (69.23%), and 10 respondents each with moderate and light physical activities had a percentage of (15.38%). The total mean was 8210.23, and the SD was 4955.89.

The association between the serum vitamin D levels and lifestyle factors (included: smoking severity, sun exposure, food intake, and physical activity), which was calculated using the Spearman correlation coefficient method was, 0.742 for smoking severity, 0.117 for sun exposure, and 0.726 for food intake by FFQ 0.742 for food intake by recall 24 hours, and 0.824 for physical activity. Most of the P values were <0.005 (significant positive correlation). There was a significant positive correlation between vitamin D levels and smoking severity, food intake by FFQ, food intake by 24-hour recall, and physical activity, except for sun exposure (**Table 6**).

The average 25(OH)D level of respondents was 23.19±8.86 ng/mL, which was included in the vitamin D insufficiency category. The 25(OH)D level was chosen as the best indicator to assess vitamin D status in the body, because it can reflect production of endogenous vitamin D3 (synthesized in the skin) and vitamin D (D2 and D3) from food. 25(OH)D also has a longer half-life, namely 3-4 weeks, compared to calcitriol, which is only 4-6 hours (Dominguez *et al*., 2021). Apart from that, the body's homeostatic process when it finds out that there is a lack of vitamin D levels in the blood is that the body will give a signal for the secretion of parathyroid hormone (PTH) and increase calcitriol synthesis in the kidneys, so that calcitriol levels will remain maintained in conditions of vitamin D deficiency (Dominguez *et al*., 2021; Charoenngam and Holick, 2020).

The results of the respondents' smoking frequency show that the majority are moderate smokers. The results of this study are supported by a study that examined the relationship between the degree of smoking assessed using the Brinkman index and early detection of chronic obstructive pulmonary disease in Indonesia, which stated that the highest degree of smoking was moderate smoking (Khasanah *et al*., 2023). This is because the majority of respondents in this study were of productive age (still working). Smoking while working is a culture in Indonesia (Salsabila *et al*., 2022).

The frequency of smoking can reduce the intake of foods containing vitamin D. This is because smoking can cause vitamin D deficiency through several mechanisms, namely the nicotine content in cigarette smoke can reduce the intake of foods containing vitamin D. This theory is proven by a study by Yang et.

al. (2022) who concluded that consumption of food containing vitamin D decreased with increasing smoking frequency. 11 This theory and research is in accordance with the results of this study, showing that the majority of respondents were moderate smokers and consumed less food containing vitamin D (Yang *et al*., 2022). Long duration of smoking was associated with decreased serum 25(OH)D levels. A study by Yuan and Ni (2022), regarding smoking and serum 25(OH)D levels, stated a dose-response relationship between smoking and 25(OH)D levels, showing tobacco smoke exposure may disrupt vitamin D levels among the general population, with an increasing temporal trend and age, gender differences in risk. It can be caused, apart from the nicotine content in cigarette smoke which can reduce the intake of foods containing vitamin D, the content of Benzo(a)pyrene or BaP in cigarette smoke can increase the catabolism of 25(OH)D to 24.25(OH)D by increasing the expression of 24-hydroxylase (CYP24A1) thereby reducing serum vitamin D levels (Mousavi *et al*., 2019).

The vitamin D status assessment category is based on the median cut-off point. Answers to the total questionnaire score of <6 are categorized as having no risk of deficiency, while having a risk of deficiency if the total score is ≥6. Most respondents were exposed to the sun between 07.00 and 09.00 (55.32%). The best time for sun exposure is from 10.00 WIB to 14.00 WIB. During these hours, UVB and UVA sunlight can stimulate human skin to produce vitamin D. If exposure to sunlight is less than 10.00 or more than 14.00, the body will not get enough vitamin D, so that human skin synthesizes little vitamin D (Raymond-Lezman and Riskin, 2023). The time of exposure is one of the important factors in the synthesis of vitamin D. Based on previous research, research was conducted on elderly women in Jakarta, Indonesia (6°south latitude) who were exposed to sunlight from 07.00 WIB to 16.00 WIB using a UV meter to obtain values MED (minimum erythemal dose) per hour. This research shows that the highest UVB intensity occurs from 11.00 WIB to 13.00 WIB in the afternoon. UVB obtained from sunlight can help the synthesis of vitamin D in the skin (Setiati, 2008).

Most respondents also use skin protection to avoid direct exposure to sunlight (93.62%), especially jackets and hats. Based on the theory, individuals who avoid sun exposure, including using sunscreen, hats, and umbrellas, are at risk of vitamin D deficiency. Using skin protective equipment is not a problem, but it is better to let your face get sun exposure 3 times a week to get enough vitamin D (Raymond-Lezman and Riskin, 2023). Vitamin D deficiency can be prevented by allowing the body to be exposed to direct sunlight for 15-20 minutes with a minimum of 40% of the skin surface exposed to sunlight. Holick's rules mention that having sunlight exposure for 25 minutes, 3 times a week at 09.00 am can meet the body's vitamin D needs (Raymond-Lezman and Riskin, 2023; Setiati, 2008).

Questions about using cosmetic products containing SPF. 42 respondents used cosmetic products containing SPF (89.36%). Cosmetic products containing SPF 8 can reduce previtamin D3 by 93% while SPF 15 can reduce it by 99%. Regular use of sunblock can significantly reduce vitamin D production in the skin. Using good sunscreen gives 15 minutes without using it on the face and arms daily, which is enough to maintain vitamin D (Kaur *et al*., 2024; Neale *et al*., 2019). Sun Protection Factor (SPF) is a means of protecting the skin from UVB rays. When the SPF value increases, protection from UVB rays also increases. Although the use of sunblock will have a risk of low vitamin D status, infrequent use will have a small impact on reducing vitamin D synthesis in the skin (Raymond-Lezman and Riskin, 2023).

In addition, smoking is considered a factor that can contribute to human skin aging. Vitamin D is the only vitamin that is synthesized endogenously in the human body. Through the skin, 7-dehydrocholesterol, with the help of sunlight (UVB radiation), will be converted into previtamin D3. Previtamin D3 is thermodynamically unstable and requires isomerization to form vitamin D3 (cholecalciferol). Cholecalciferol will then move from the skin to the systemic circulation, then through an enzymatic process in the liver mediated by 25-hydroxylase to form 25-hydroxyvitamin D (also called 25-hydroxycholecalciferol or 25(OH)

D or calcidiol). Increased skin aging can significantly reduce the ability to convert 7-dehydrocholesterol into previtamin D (Dominguez *et al*., 2021; Passeron *et al*., 2019). In this study, qualitative calculations were not carried out for the duration of sun exposure obtained by research respondents, which is a limitation of this study.

The average intake of food containing vitamin D consumed by research respondents using both methods of measuring dietary patterns was almost the same, namely, using the SQ-FFQ method (5.75 ± 5.68 mcg/day), while using the 24-hour food recall (5, 77±5.72 mcg/day). The results in Table 4.3 using the SQ-FFQ method show that only 10 (21.28%) respondents stated that they consumed enough foods containing vitamin D in accordance with the recommended RDA for Vitamin D (minimum 15 mcg/day) whereas with the 24 hour food recall method, showed that only 9 (19.15%) respondents stated that they consumed enough foods containing vitamin D according to the recommended RDA for Vitamin D (minimum 15 mcg/day). Differences in the results of these two methods may occur because both methods rely heavily on respondents' memories, especially the SQ-FFQ method, which asks about food consumption in the last month. In the 24-hour food recall method, there is the flat slope syndrome, namely the tendency for thin respondents to report consuming more (overestimate) and for obese respondents to tend to report less (underestimate).

The food that contains vitamin D, most frequently consumed by respondents, is eggs. Eggs are a source of vitamin D. The part of the egg that contains the highest vitamin D is the egg yolk, which contains 5.4 mcg of vitamin D per 67 grams. A study regarding the loss of vitamin D during the egg cooking process has been published. The vitamin D and 25(OH) D in eggs are lost, in similar amounts, during home cooking: Hard-boiled eggs (10 minutes of cooking) will lose about 10% of the vitamin D and 25(OH)D, scrambling an egg for 3 minutes lost around 20% of vitamin D and 25(OH)D, whereas when eggs were baked for 40 minutes around 60% of vitamin D and 25(OH)D were lost (Barnkob *et al*., 2020). Most of the respondents in this study consumed eggs that had been cooked first, namely fried/boiled. One egg, if converted, produces 60g. In the Nutrisurvey application, eggs with a fried/boiled cooking process weighing 60g both contain 0.6 mcg of vitamin D. This is one of the reasons why the average vitamin D consumption of research respondents is less than the RDA recommendation. Vitamin D is a minimum of 15 mcg/day (Mendivil, 2021).

Apart from eggs, fish is a food source that contains vitamin D. The frequency of fish consumption can affect vitamin D status. A meta-analysis study investigating the effect of fish consumption in RCT trials on serum 25(OH)D levels in healthy adults, stated that fish consumption was minimal. 2 times a week or the equivalent of 300g/week for at least 4 weeks can increase serum 25(OH)D levels, the research also stated that compared to the control group (which on average consumed meat) fish consumption could increase serum 25(OH)D levels the average is 1.76 ng/mL, the type of fish also plays an important role, namely consumption of fatty fish produces an average difference of 2.72 ng/mL, while for lean fish the average difference is 0.76 ng/mL (Mendivil, 2021). The type of fish most consumed by research respondents is catfish, which is a group of fatty fish. In the Nutrisurvey application, 70g of catfish contains 7 mcg of vitamin D. Respondents' average consumption of catfish is 7.62-7.66 grams/day, with the result of vitamin D in the Nutrisurvey application being 0.8 mcg/day. Indonesians still rarely consume fish; Indonesians consume tofu, tempeh, and chicken more often, as proven by the results of interviews with respondents in this study who used the 24-hour food recall method. This is one of the reasons why the average vitamin D consumption of research respondents is less than the recommended RDA for vitamin D, namely a minimum of 15 mcg/day.

The food source that contributed the greatest value of vitamin D in this study was milk, with a vitamin D content of 7.5 mcg/35g, namely 2.1 mcg/day. Milk with a vitamin D content of 7.5 mcg/35g is a fortified product that contains vitamin D. A study by Torres et. al. (2020), examined the relationship between milk consumption and vitamin D status in the United States population, stating that milk

intake (especially low-fat milk) was positively associated with serum vitamin D status and with a 31-42% higher probability of meeting serum 25(OH)D levels. Recommended (>50 nmol/L) among all age groups, and research results also show that milk consumption consistently has higher serum 25(OH)D levels (Torres *et al*., 2020). Another thing that could cause research respondents not to meet the recommended RDA for vitamin D is that smoking can reduce the intake of foods containing vitamin D. It can happen because when someone inhales cigarette smoke, as many as 4000 chemicals will be inhaled and enter the lungs, especially nicotine (Yang *et al*., 2021). Nicotine can suppress a smoker's appetite. The nicotine content in a cigarette is 0.3–2.8 mg. Nicotine will be quickly absorbed into the bloodstream and carried to the brain, and will bind to nicotinic receptors, which are connected to ion channels and cause cations, including sodium and potassium, to enter and release various neurotransmitters. This process causes the release of catecholamines, dopamine, serotonin, norepinephrine, GABA, and other neurotransmitters, so that the central nervous system will release neurotransmitters that are related to decreased appetite. The higher the level of nicotine in the blood, the greater the postsynaptic stimulation of nicotinic receptors. This decrease in appetite in smokers can cause a decrease in food intake containing vitamin D (McEwan *et al*., 2022). Intake of food containing vitamin D is significantly correlated with serum 25(OH)D levels (Andrade *et al*., 2022). There has been no research related to reducing the intake of foods containing vitamin D in men who are active smokers. This study is the first study to examine the effect of smoking activity on the intake of foods containing vitamin D in male active smokers.

The instruments used to measure physical activity have various methods. For example, by using accelerometers, pedometers, and self-report questionnaires (IPAQ, Physical Activity Readiness Questionnaire (PAR-Q). This research uses self-report questionnaire instruments because they have the advantage of lower costs. Respondents are not burdened, and getting answers from physical activity activities during the last week from respondents, of course, there are also shortcomings, namely that there can be a slight data bias because the data obtained is only based on the respondents' memories (Anindya *et al*., 2022; Andriyani *et al*., 2020; Suryadinata *et al*., 2020). Previous research by Lorensia *et al*. (2021) involved 124 adult smokers in Surabaya, Indonesia, and showed that the level of physical activity did not correlate with respiratory problems; these problems were more common in the vigorous category.

Conclusion

Most of the respondents' classifications had a level of insufficiency in vitamin D levels. The most consumed were eggs (37.66g), then pindang fish (10.21g), milk with a Vitamin D content of 7 mcg/35g (9.93g), while the least consumed was anchovies (0.89g). The average intake of foods containing vitamin D consumed by respondents was 5.77±5.72 mcg/day, and only 9 people (19.15%) consumed enough foods containing vitamin D. Vitamin D levels had a significant effect on smoking severity (P=0.000), food intake (P=0.000), and physical activity (P=0.000). The higher the food intake and physical activity, the higher the vitamin D levels. However, the results also showed that the higher the exposure to smoking, the higher the vitamin D levels. However, vitamin D levels are not related to sun exposure (p-value = 0.624) in active smokers.

Acknowledgment

This research was funded by the Research and Community Service Institute (LPPM) of Universitas Surabaya.

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KEMAS 21 (2) (2025) 301-308

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Work-Related Factors, Exercise Habits, and Individual Characteristics on Musculoskeletal Disorders among Indonesian Young Dentists

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Article Info

Article History:
Submitted: December 2024
Accepted: September 2025
Published: October 2025

Keywords:
Dental, Ergonomics; Musculoskeletal Disorders; Young Dentist

DOI
https://doi.org/10.15294/kemas.v21i2.17220

Abstract

MSDs disorders among dentists are one of the most common complaints. A high prevalence of MSDs among dentists is evident, with 63.5% of young Indonesian dentists experiencing musculoskeletal symptoms. This study aims to explore risk factors that can increase the incidence of MSDs among young dentists. Methods: This study employed a cross-sectional design with a population of 162, which served as the entire sample. The questionnaire instrument contains questions about gender, age, weight, height, smoking habits, daily sleep duration, exercise habits, length of work, and length of service. There is also a standard questionnaire, namely the Nordic Body Map, to evaluate musculoskeletal disorders in individuals. Data analysis used the chi-square test and the multiple logistic regression test. Results: The highest MSDs were reported to occur in the upper back (69.8 %), followed by the lower back (67.3%) and neck (63.6%), while the lowest prevalence was reported in the ankle (8.6%). Gender, length of service, and exercise habits are associated with the occurrence of MSDs. Conclusion: The prevalence of MSDs among young dentists is still high. Length of service is the most influential risk factor.

Introduction

Musculoskeletal disorders are defined as any form of pain or injury caused by the musculoskeletal system (MS) (i.e., muscles, joints, ligaments, tendons, or nerves) (Edrees *et al*., 2024) . Musculoskeletal Disorders (MSDs) are a major health burden for the dental profession. The causes of MSDs are a direct result of repetitive work or non-ergonomic practices in the workplace (Rajvanshi *et al*., 2015) and the use of work tools that cause vibration hazards. Broadly, several studies have investigated that the prevalence of MSDs is high among dentists (Batham and Yasobant, 2016; Lietz, Ulusoy and Nienhaus, 2020; Ohlendorf *et al*., 2020) . Another study on the prevalence of MSDs in dentists worldwide is described to vary between 10.8% - 97.9% (Ohlendorf *et al*., 2020) . Data from a review article explains that in the Health sector, the estimated prevalence of degenerative lumbar spine disease is 21% and osteoporosis of the hands is 37% which occurs in dentists as a result of their work (Greggi *et al*., 2024). A high prevalence of MSDs among dentists is evident, with 63.5% of young Indonesian dentists experiencing musculoskeletal symptoms (Lietz *et al*., 2020).

MSDs occur when someone works in a work position that can expose the human body to certain loads with certain positions that occur repeatedly (Punnett and Wegman, 2004). This causes the joints, muscles, and tendons to experience excessive force in uncomfortable work positions. Intense work activities require large muscle exertion that causes fatigue and has the potential for MSDs. (Fernandez, 1995) . Previous studies have shown that 72.6% of Dental Personnel experience MSDs (Davoudi-

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pISSN 1858-1196
eISSN 2355-3596

Kiakalayeh *et al*., 2017). In a study conducted on dental students, musculoskeletal symptoms were found (Zafar and Almosa, 2019). Several factors contribute to the emergence of this disorder, which are very multifactorial, including genetic factors, environmental factors, and work factors in the form of body posture and length of work (Chan *et al*., 2018; Soo *et al*., 2023). As a dentist, the work activities carried out every day during practice pose a risk of MSDs. Work that sits for a long time in an uncomfortable position, uses great strength in carrying out dental service practices, and is exacerbated by movements that (Meisha *et al*., 2019; Greggi *et al*., 2024). These activities are not balanced with sufficient rest and recovery time, so the risk of MSDs becomes greater. MSDs can disrupt daily activities, such as lost school time(Lestari *et al*., 2020).

Research on MSDs in dental students is still limited, while most of the existing studies are cross-sectional and do not provide a long-term picture. Variability in measurement methods in MSDs research causes data inconsistency and makes it difficult to compare results between studies. In addition to well-known factors such as non-ergonomic posture and long working hours, sleep quality is thought to play a significant role in the prevalence of MSDs among dental students. Students who experience sleep disturbances or poor sleep quality may be more susceptible to MSDs because the body does not get enough time for recovery and regeneration. Analysis of these factors is important to obtain a more comprehensive picture of the causes of MSDs and to develop more effective preventive measures.

Methods

This study used a cross-sectional design, and the study was conducted in September 2024. The population of this study was 162 young dentists at the Dental and Oral Hospital of Muhammadiyah University of Semarang. This study used the total population as a sample, so that all young dentists would be included in the study. This. The independent variables in this study are gender, age, BMI, smoking habits, sleep quality, exercise habits, and length of service. The dependent variable is musculoskeletal disorders.

Data collection was conducted by the interview method using a questionnaire instrument containing questions about gender, age, weight, height, smoking habits, how long to sleep in a day, exercise habits, length of work, and length of service. And there is a standard questionnaire, namely the Nordic Body Map, which is a measuring tool used to evaluate musculoskeletal disorders in individuals. This questionnaire is designed to systematically map the location of pain or discomfort in the body. This tool involves five main anatomical areas: neck, upper back (thoracic), lower back (lumbar), shoulders, and arms and hands. This study was approved by young dentists who filled out and signed the informed consent form, after which interviews and BMI measurements were conducted.

The data analysis conducted was an univariate analysis by presenting data in the form of a table containing frequencies and percentages between factors. Bivariate analysis was conducted by testing the relationship between factors and MSDs using the chi-square test and Fisher's exact test. Multivariate analysis was used to determine the factors most related to MSDs with multiple logistic regression tests. The software used for data analysis in this study was IBM SPSS Statistics 21. This research has received an ethical certificate from the ethics committee, and the number of the ethics certificate is 001/RSGM/KEPK/PE/2024.

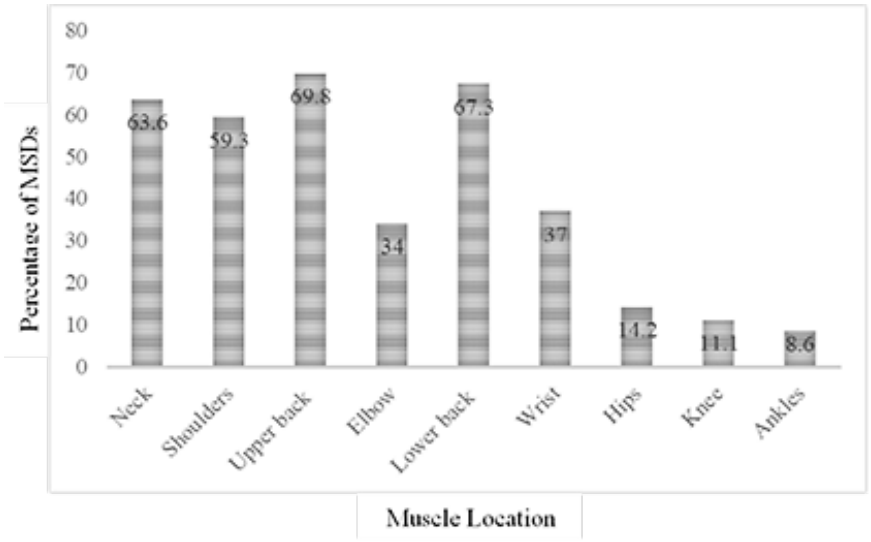
Results and Discussion

This study was dominated by women as respondents (72.8%), while the average age was 24 years. The BMI category most experienced by respondents was obesity 1 (40.7 %). Many had good sleep quality (78.4 %), and more respondents did sports than those who did not (56.2%). Only 13.6 % of respondents worked more than 8 hours, and most of the respondents worked less than 10 years (38.3%). Among the 162 respondents, at least 87% felt pain on one side of their body. Figure 1 shows that the highest prevalence of MSDS pain was reported in the upper back (69.8%), followed by the lower back (67.3%) and neck (63.6%), while the lowest prevalence was reported in the ankle (8.6%).

TABLE 1. Information on Respondent Characteristics

Variable	f (%)	Mean±SD
Gender		
Man	44 (27.2)	
Woman	118 (72.8)	
Age		
21-24	95 (58.6)	24.20±2.067
25-28	67 (41.4)	
IMT		
BB Less	7 (4.3)	24,560±2,7943
BB Normal	27 (16.7)	
Advantages of BB	61 (37.7)	
Obesity 1	66 (40.7)	
Obesity 2	1 (0.6)	
Smoking habit		
Non-Smoker	143 (88.3)	
Smoker	19 (11.7)	
Sleep quality		
Good	127 (78.4)	7.01±1.520
Bad	35 (21.6)	
Exercise Habits		
Yes	91 (56.2)	
No	71 (43.8)	
Length of working		
<8 hours	22 (13.6)	8.45±0.819
>=8 hours	140 (86.4)	
Years of service		
<5 years	62 (38.3)	12.73±9.790
>=5 years	100 (61.7)	
MSDs Complaints		
No	21 (13)	3.64±2.411
MSDs	141(87)	

Source: Primary Data, 2024



Source: Primary Data, 2024

TABLE 2. Risk factors for MSDs

Variables	Category	MSDs						PR	95%CI	P value
		No Pain		Pain		Total				
		f	%	f	%	f	%			
Gender	Man	10	22.7	34	77.3	44	100.0	2.4	1,118-7,319	0.046
	Woman	11	9.3	107	90.7	118	100.0			
BMI	Normal	3	11.1	24	88.9	27	100.0	0.8	0.222-2.978	1,000
	Abnormal	18	13.3	117	86.7	135	100.0			
Age	21-24	12	12.6	83	87.4	95	100.0	0.9	0.369-2.355	1,000
	25-28	9	13.4	58	86.6	67	100.0			
Smoke	Non-smoker	16	11.2	127	88.8	143	100.0	0.4	0.112-1.109	0.077
	Smoker	5	26.3	14	73.7	19	100.0			
Sleep quality	Good	16	12.6	111	87.4	127	100.0	0.9	0.293-2.552	0.780
	Bad	5	14.3	30	85.7	35	100.0			
Sports Habit	Yes	17	18.7	74	81.3	91	100.0	3.3	1,233-12,011	0.027
	No	4	5.6	67	94.4	71	100.0			
Length of working	<8 hours	9	40.9	13	59.1	22	100.0	4.8	2,622-20,801	0,000
	>=8 hours	12	8.6	128	91.4	140	100.0			
Years of service	<5 years	3	4.8	59	95.2	62	100.0	0.3	0.065-0.823	0.029
	>=5 years	18	18	82	82	100	100.0			

Source: Primary Data, 2024

TABLE 3. Results of Multivariate

Variables	β	p	Exp β
Gender	1,141	0.036	3,130
Length of working	2,350	0,000	10,489
Exercise Habits	1,602	0.012	4,963

Source: Primary Data, 2024

The results of the chi-square test explain that there is a relationship between gender, exercise habits, length of service, and MSDs (Table 2). The results of the multivariate test explain that the most influential variable is length of service (Table 3).

Most studies report that neck pain is the most common complaint experienced by dentists. (Ohlendorf *et al*., 2020; Gandolfi *et al*., 2021; Hussein, Mando and Radisauskas, 2022; Singh *et al*., 2022; AlSahiem *et al*., 2023). When dentists work in a bent and twisted neck position, as well as a static position without rest, these are the most frequently reported causes of neck pain. (Presoto, Petromilli and Sasso, 2016; José *et al*., 2017). Other studies reported this was related to a decrease in the use of dental magnifying glasses of less than a quarter, even though their use has been proven to be efficient in reducing MSDs because it prevents improper bending of the neck, and the work posture is considered better when using dental magnifying glasses. (Plessas, 2018; Carpentier *et al*., 2019; Lietz, Ulusoy and Nienhaus, 2020) Another factor that may contribute to neck pain is the prolonged use of electronic devices every day. A study reported that the use of portable electronic devices (laptops, tablets, and phones) resulted in greater neck flexion, which can increase chronic neck pain. (Lee *et al*., 2021)

This study found that pain in the upper back was the most common. When practicing, young dentists sit for a long time, and the upper back tends to bend often, so that the curvature of the spine is shaped like the letter C. In addition, several young dentists' practices require working in alternating standing and sitting positions, which further increases the risk. Studies report that upper and lower back pain will be more severe than in those who only stand or sit. (Grado *et al*., 2019) Previous studies also reported that most (72.6%) dentists felt pain and discomfort in the upper and lower back areas, which were quite high compared to other specialist doctors. (Younis *et al*., 2022)

Previous studies have reported that women are at higher risk of MSDs than men (Plessas, 2018; Gandolfi *et al*., 2021). This may be attributed to differences in muscle mass, joint structure, and hormonal influences. Estrogen, for instance, affects ligament laxity and pain perception, potentially increasing susceptibility to musculoskeletal strain and injury. Additionally, women generally have lower upper-body strength, which can lead to greater physical strain during certain tasks, thereby contributing to the development of musculoskeletal disorders (Bouhet *et al*., 2024). Likewise, this study reports that women are at greater risk of MSDs. Married women have additional tasks at home compared to those who are single. Likewise, women during menopause will be at greater risk compared to younger women due to osteoporosis, osteoarthritis, and sarcopenia. (Khadilkar, 2019).

The results of the study prove that there is a relationship between the length of work and MSDs. Long working hours increase the risk of MSDs, as prolonged duration of work leads to extended exposure to repetitive movements, static postures, and biomechanical stress. These factors can cause microtrauma to muscles, tendons, and ligaments, triggering an inflammatory response that contributes to the development of musculoskeletal disorders(Eyvazlou *et al*., 2021). Young dentists who practice for extended periods with poor posture are particularly at high risk, as continuous strain without adequate recovery time can result in cumulative tissue damage. This is in line with previous studies, which reported that longer working hours per day and per week are associated with a higher prevalence of MSDs—especially among operators working more than 8 hours per day and more than 40 hours per week, where up to 90% report experiencing one or more MSDs. (Gandolfi *et al*., 2021)

Several studies have shown that the prevalence of chronic pain is significantly related to years of experience (Grado *et al*., 2019; Gandolfi *et al*., 2021; Younis *et al*., 2022) . Similarly, this study found that the prevalence of MSDs is higher in young dentists with longer working periods. The longer the working period, the greater the cumulative exposure to ergonomic risk factors such as awkward postures, repetitive movements, and static muscle loading. These continuous mechanical stresses can lead to microtrauma in musculoskeletal tissues, which, over time, trigger an inflammatory response, tissue degeneration, and chronic pain (Alzayani *et al*., 2021). Young dentists who fail to maintain proper working posture from the beginning of their careers are more likely to develop poor ergonomic habits, which accelerate musculoskeletal strain. Previous studies have also reported that back pain can appear shortly after entering the profession, with prevalence increasing from 72% in those with less than 3 years of experience to 84% in those with 3 to 6 years of experience (Grado *et al*., 2019).

More than half of the young dentists in this study did sports (56.2 %). This finding is supported by several previous studies stating that most participants did some physical exercise (AlSahiem *et al*., 2023) . However, it can be seen that young dentists who experience MSDs are more common among dentists who do not exercise (94.4 %). The prevalence ratio results also show that young dentists who do not exercise are 3.3 times more likely to be at risk than those who do exercise. Regular exercise can help prevent and reduce the intensity of MSDs (Hashim and Al-ali, 2013; Feng *et al*., 2014) , and can provide mental relaxation from the high stress experienced by young dentists during work and training (Tezel *et al*., 2005) which leads to a healthier lifestyle and reduces the risk of MSDs (Hildebrandt *et al*., 2000) . Regardless of the type of work, regular exercise, training, and yoga are important preventive measures against many chronic diseases (Booth *et al*., 2012). A cross-sectional design only allows the establishment of possible relationships between MSDs and the research variables investigated. In addition, there is a possibility of prevalence bias because MSDs felt during a certain period may not have occurred at the time of the study.

More than half of the young dentists in this study reported engaging in physical exercise (56.2%). This finding aligns with several previous studies indicating that a majority of participants performed some form of physical activity (AlSahiem *et al*., 2023). However, MSDs were found to be more prevalent among young dentists who did not exercise (94.4%). The prevalence ratio also indicates that young dentists who do not engage in regular physical activity are 3.3 times more likely to develop MSDs compared to those who do exercise. From a pathophysiological perspective, regular physical activity plays a critical role in maintaining musculoskeletal health by improving muscle strength, flexibility, and joint stability, which can reduce biomechanical strain and prevent tissue damage. Exercise also promotes better blood flow to muscles and tendons, facilitating nutrient delivery and waste removal, thereby reducing inflammation and supporting tissue repair (Rhim *et al*., 2022). Moreover, regular physical activity contributes to stress reduction by modulating cortisol levels and enhancing endorphin release, which not only supports psychological well-being but also decreases muscle tension commonly associated with stress-induced MSDs (Tezel *et al*., 2005; Hildebrandt *et al*., 2000). Therefore, incorporating exercise routines, including strength training, stretching, or yoga, serves as a preventive strategy against the development of chronic musculoskeletal conditions (Booth *et al*., 2012). Nevertheless, due to the cross-sectional nature of this study, only associations—not causal relationships—can be inferred, and there is a possibility of prevalence bias, as reported MSDs may not reflect current or persistent conditions

Conclusion

This study shows a high prevalence of MSDs among young dentists, even though only 1 body part is complained of. Gender, length of work, and exercise habits are the most influential factors in increasing the risk of MSDs. Dental schools should encourage the application of ergonomic principles and stretching in between practices. Adding sports

classes outside the curriculum and preparing easily accessible sports facilities on campus are arrangements that can minimize the negative impact of MSDs among young dentists. Future research needs to conduct studies with a cohort design so that the process of MSDs occurring over time can be seen, and what factors can increase the risk.

Acknowledgement

The author would like to thank the Research and Community Services Board of Universitas Muhammadiyah Semarang for funding the research and for assisting during the article's writing.

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KEMAS 21 (2) (2025) 309-320

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Health Beliefs and Husband's Preparedness in Supporting Postpartum Contraceptive Use

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Article Info

Article History:
Submitted: April 2025
Accepted: September 2025
Published: October 2025

Keywords:
correlational study; family planning; health belief model; husband's preparedness; postpartum contraception

DOI
https://doi.org/10.15294/kemas.v21i2.24085

Abstract

Use of postpartum contraceptives is critical to the prevention of unwanted pregnancies and enhancing maternal and child health. Yet, husbands' support for the use of contraceptives is still low based on cultural beliefs and inadequate knowledge. It is important to understand how health belief influences husbands' readiness in order to improve family planning. This study will analyze the association between health beliefs and husbands' readiness to support postpartum contraceptive use. A cross-sectional correlational descriptive design was employed with 170 husbands of postpartum women in Samarinda, Indonesia. Consecutive sampling was used, and data were collected using validated tools modeled after the Health Belief Model (HBM) and a scale of a husband's preparedness. The tools were found to have high reliability, with Cronbach's alpha values ranging from 0.761 to 0.988. Data analysis included univariate descriptive statistics and Spearman's rank correlation to quantify the relationship between preparedness and the health beliefs of husbands. Researchers found a significant positive relationship between preparedness and health beliefs of husbands in support of postpartum use of contraceptives ($p = 0.01$, $r = 0.745$). The greatest correlation was between perceived susceptibility and concern ($r = 0.548$, $p = 0.00$), then self-efficacy and concern ($r = 0.534$, $p = 0.00$). Husbands' health beliefs play a crucial role in their willingness to support postpartum contraceptive use. Anchoring on education programs that reinforce health beliefs will enhance husbands' participation in family planning.

Introduction

Postpartum contraceptive use is necessary for preventing unwanted pregnancies and improving maternal and child health outcomes worldwide. However, it is underreported, especially in low- and middle-income countries, where postpartum contraception is used by only 62% of women (Asresie *et al*., 2020). This gap in contraceptive coverage is a significant public health problem warranting intensive research and targeted interventions. The most deciding factor is the poor support of husbands for standing by their wives' use of contraceptives, which largely dictates the success rate of family planning (Amuzie, Nwamoh, Ukegbu, Umeokonkwo, *et al*., 2022). The husbands primarily suggest reasons such as preferring to have additional children or resistance from the family, typically overlooking maternal and child health concerns (Bibi *et al*., 2019).

Social and cultural conventions tend to place men as key decision-makers in reproductive health issues, but their attitudes and understanding of contraception can be appalling or guided by misinformation. Additionally, religious misconceptions, including linking contraception to abortion or sin (Ali *et al*., 2022; Barro *et al*., 2021), further weaken family planning initiatives and act

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pISSN 1858-1196
eISSN 2355-3596

as barriers to successful postpartum use of contraception. In Uganda, for instance, parents discourage their adolescent daughters from using contraception because they perceive that it promotes promiscuity (Vuamaiku *et al*., 2023). Such religious and cultural barriers need culturally sensitive interventions that attempt to break down underlying misconceptions and beliefs. Avoiding postpartum contraception has risky consequences on maternal and child health, and its ramifications extend beyond family units.

The first 12 months after delivery are critical, and during this time, mothers are highly vulnerable to health complications like hemorrhage, infection, and malnutrition (Cleland *et al*., 2012; Engelbert *et al*., 2021; Rwabilimbo *et al*., 2021). It has been established that pregnancies occurring within 18 months of the previous delivery are associated with high risks of maternal mortality, preterm birth, and low birth weight. Short inter-pregnancy intervals are associated with low birth weight and high neonatal mortality, creating a cycle of poor health outcomes (Davanzo *et al*., 2007; Zhu *et al*., 2001). Furthermore, for those who wish for another pregnancy sooner, the risk of miscarriage and ectopic pregnancy is also higher (Lakha & Glasier, 2006). According to the Declaration for Collective Action for Postpartum Family Planning, spacing births by at least two years can reduce maternal mortality by over 30% and infant mortality by 10% (Hounkponou *et al*., 2022). Husbands' active involvement is required for the effective usage of postpartum contraception since, in the majority of cultures, they hold the final decision-making authority (Sarfraz *et al*., 2023). The patriarchal nature of the majority of societies makes women's reproductive choices contingent upon male acceptance and approval.

Effective couple communication enables contraceptive planning (Owuor & Derose, 2004), and husbands' support and approval are significant in their wives' decision-making (Prata *et al*., 2017; Ruderman *et al*., 2022). However, some husbands are not concerned about family planning due to a lack of appreciation and trust in the program (Amuzie, Nwamoh, Ukegbu, Umeokonkwo, *et al*., 2022). Confidence in family planning interventions can be achieved by increased knowledge and favorable attitudes among husbands, making them more ready to facilitate the use of postpartum contraception (Hernandez *et al*., 2022). Education interventions targeting men have been reported to show promise in enhancing contraceptive uptake and continuation. Therefore, the discussion on contraception should be done during pregnancy to help couples reach consensus and strengthen the wife's attitude regarding postpartum family planning (Wuni *et al*., 2018; Zimmerman *et al*., 2021).

Husbands' approval and emotional support are key to empowering women to use contraception after delivery (Rakhshani *et al*., 2005). Also, involving families in family planning conversations can allow women to make shared decisions and reduce the emotional costs of contraceptive decision-making (Underwood *et al*., 2019). Family-centered contraceptive counseling interventions have been associated with improved communication patterns and reduced inter-spousal conflict. By appreciating the efforts of their wives, the husbands can motivate them more to use contraception without fear or anticipation of any side effects (Idris *et al*., 2021). When husbands demonstrate pride, respect, and understanding, they acknowledge the physical and emotional challenges of childbirth and support their wives' health and independence (Widyastuti *et al*., 2023).

Method

This research employed a cross-sectional correlational descriptive design to determine the correlation between health beliefs and husbands' willingness to enable postpartum use of contraceptives. This was a suitable design because it allows for the investigation of associations between variables at a point in time, which is an appropriate means of investigating relationships between psychological variables and behavioral intentions. The cross-sectional study is a precious instrument to establish up-to-date husbands' attitudes and readiness, but it is inexpensive and feasible in resource-limited settings. The study was conducted in the Community Health Center (Puskesmas) Samarinda Regency, Indonesia, which is the

central public health center for residents in the region. The reason for selecting this site was that Puskesmas centers provide the majority of Indonesia's family planning services and are the normal care setting in which postpartum contraceptive counseling is provided. The study population consisted of husbands of women who had just given birth and were attending postpartum care at the center. 170 participants were recruited using consecutive sampling, which involved enrolling all the eligible participants who fit into the inclusion criteria within the data collection time. The inclusion criteria were: (1) husbands of legal wives, (2) husbands whose wives had given birth, and (3) husbands who were ready to participate in the study. Participants who did not agree to participate were not allowed in the study to ensure voluntary participation and quality data.

Health Belief Instrument: Based on the Health Belief Model (Rosenstock, 1974), this instrument assessed husbands' beliefs about family planning programs and the use of contraceptives. The instrument was adapted to the Indonesian context and validated through expert review and pilot testing. There were 20 items on five dimensions: perceived susceptibility (4 items), perceived severity (4 items), perceived barriers (4 items), perceived benefits (4 items), and self-efficacy (4 items). The responses were scored on a 5-point Likert scale, from 1 (very unsure) to 5 (very confident) for the positive items, and reverse scored for the negative items. The greater the score, the higher the health beliefs and the more positive the family planning attitudes. The instrument was found to have acceptable reliability, with Cronbach's alpha coefficients for each factor: perceived susceptibility (0.861), perceived severity (0.837), perceived barriers (0.893), perceived benefits (0.796), and self-efficacy (0.988). Husband's Preparedness Scale: Based on research on husbands' involvement in supporting postpartum use of contraception (Owuor & Derose, 2004; Prata *et al*., 2017; Ruderman *et al*., 2022), the scale was designed to measure husbands' readiness to support their wives' contraceptive decision. It was designed to measure a number of aspects of readiness, including emotional, practical, and cognitive support. It consisted of 12 items in three dimensions: concern (6 items), ability to facilitate (3 items), and appreciation (3 items). Items were rated on a 5-point scale (1 = very unprepared to 5 = very prepared), with higher scores indicating higher levels of being prepared to help postpartum use of contraceptives. Reliability of the instrument was determined by Cronbach's alpha coefficients for each dimension: concern (0.935), ability to facilitate (0.924), and appreciation (0.761).

The questionnaire was provided in Indonesian to ensure cultural appropriateness and respondent understanding. Translation and back-translation procedures were followed to maintain the validity of the original instruments. Demographic data, such as age, educational level, occupation, and earnings, were also collected to facilitate more comprehensive analysis and place the findings in perspective. The questionnaire link was sent to husbands with the assistance of trained nurses at the Puskesmas from January 4 to January 22, 2024, and ensured standardized data practices. The respondents provided informed consent before they completed the questionnaire, and researchers maintained strict confidentiality practices throughout the study. Researchers verified data accuracy and completeness and requested direct clarification from the respondents in the event of incomplete or unclear responses during follow-up contact. Data were statistically examined employing univariate and bivariate analysis techniques appropriate to the research objectives and data type. Univariate analysis provided descriptive statistics in the form of percentages for each health belief dimension and husband's readiness to provide a clear understanding of the nature of the sample. Normality testing was performed using the Shapiro-Wilk test to determine the appropriate statistical analysis technique. Bivariate analysis used the Spearman rank correlation test to contrast health beliefs with husbands' readiness, as the two variables were ordinal and non-normally distributed. The significance level was $p < 0.05$, and the effect sizes were interpreted based on Cohen's criteria for correlation coefficients.

Ethical approval was provided by the Muhammadiyah University of East Kalimantan Research Ethics Committee (Ref.

No. 023/KEPK-UMKT/I/2024) in upholding international standards of human research ethics. The study purpose, duration of participation, data confidentiality procedures, and participant rights as a study participant were explained to the participants. The study complied with the principles of the Declaration of Helsinki and saw to it that all ethical considerations were addressed. It was voluntary cooperation and the right to withdraw at any time without penalty or negative consequences. The questionnaire was designed not to cause distress or discomfort to answer, with sensitive questions being set in non-judgmental language.

Result and Discussion

Table 1 indicates that 45.71% of the respondents were in the age group of 36-45, the largest age group in the study sample. The prevalence of the subjects in this age bracket means the majority of the husbands were at the peak reproductive ages and perhaps with families formed and experience accumulated, which influences their family planning decisions. Besides that, there are 32.94% of 26-35 years old, and 22.35% of 17-25 years old, which is with the effect of having extensive age coverage in order to enhance the credibility of the findings. The age profile is reflective of Indonesian fertility and marriage patterns, where men wed in their late twenties and early thirties. With regard to educational attainment, 52.35% were at the Diploma or Bachelor's level, and this indicates that more than half of the respondents had higher educational qualifications. This level of education points to the fact that the sample included men with relatively good literacy levels and perhaps better exposure to health information. Further, 29.41% achieved senior high school, 10% junior high school graduation, and 8.24% primary school graduation, showing education diversity in line with that of the general population attributes. Higher educational levels have been correlated with better family planning attitudes and increased involvement in reproductive health decisions.

In relation to their employment status, 64.71% worked as self-employed employees, which is common in the Indonesian economy, where micro-enterprise labor and the informal sector are predominant. This pattern of employment may influence family planning decisions through its economic security and ability to access healthcare services. Additionally, 21.76% were government employees, and 13.53% worked in the private sector, providing representation from different employment sectors. Employment status can significantly influence men's involvement in family planning, with self-employed individuals often having more flexible schedules to accompany their wives to healthcare facilities. Economic status showed 65.3% earned above the minimum wage, while 34.7% earned below it, indicating relatively good economic conditions among participants that may facilitate access to contraceptive services.

TABLE 1. Characteristics of Husbands Whose Wives Use Postpartum Contraception (n = 170)

Variable	Category	f	%
Age	17-25 years old	38	22.35
	26-35 years old	56	32.94
	36-45 years old	76	45.71
Education Level	Not attending school/primary school	14	8.24
	Junior high school	17	10.00
	Senior High School	50	29.41
	Diploma / Bachelor's Degree	89	52.35
Employment	Government employees	37	21.76
	Private employees	23	13.53
	Self-employed	110	64.71
Income per Month	≤ UMK Rp 3.300.000	59	34.70
	> UMK Rp 3.300.000	111	65.30

TABLE 2. Descriptive Statistics of Health Beliefs and Husbands' Preparedness to Support Postpartum Contraceptive Use (n = 170)

Variable	Dimensions	Mean	Standard Deviation
Health Beliefs	Perceived susceptibility	3.18	0.610
	Perceived severity	2.32	0.530
	Perceived barriers	2.51	0.587
	Perceived benefit	2.22	0.472
	Self-efficacy	2.36	0.535
Husband's preparedness	Concern	3.21	0.669
	Ability to facilitate	2.48	0.543
	Appreciation	2.22	0.473

Table 2 showed that perceived susceptibility had the highest mean score (M = 3.18, SD = 0.610), indicating that husbands generally recognized the risks associated with unplanned pregnancies and short birth intervals. This finding suggests that participants were aware of the potential health consequences for both mothers and children when contraception is not used appropriately. The relatively high score for perceived susceptibility is encouraging as it represents a foundation for promoting family planning behaviors. Perceived susceptibility is considered a key motivator for health behavior change, as individuals who recognize their vulnerability to health risks are more likely to take preventive actions. The second highest score was for perceived barriers (M = 2.51, SD = 0.587), followed by self-efficacy (M = 2.36, SD = 0.535), perceived severity (M = 2.32, SD = 0.530), and perceived benefit (M = 2.22, SD = 0.472). These moderate scores suggest that while husbands recognized some barriers to contraceptive use, they also demonstrated reasonable confidence in their ability to support their wives' family planning decisions. The relatively low score for perceived benefits indicates an area for improvement in family planning education programs. Research has shown that emphasizing the benefits of contraception, including health, economic, and social advantages, can significantly improve acceptance and support for family planning programs.

For husbands' preparedness dimensions, concern showed the highest mean score (M = 3.21, SD = 0.669), indicating that husbands expressed genuine care and worry about their wives' reproductive health and family well-being. This finding suggests that emotional support and concern are prominent aspects of husbands' preparedness to support contraceptive use. The high concern score reflects the importance of emotional factors in family planning decisions and suggests that husbands are motivated by care for their families. Emotional support from partners has been identified as a crucial factor in contraceptive use and continuation, particularly in cultures where male approval is important. The scores for ability to facilitate (M = 2.48, SD = 0.543) and appreciation (M = 2.22, SD = 0.473) were moderate, suggesting areas where targeted interventions could enhance husbands' preparedness.

As shown in Table 3, all health belief attributes showed significant positive correlations with dimensions of husband's preparedness, demonstrating the comprehensive relationship between cognitive factors and behavioral intentions. The strongest correlation was between perceived susceptibility and concern (r = 0.548, p = 0.00), indicating that husbands who recognized the risks of unplanned pregnancies were more likely to express concern and emotional support for their wives' contraceptive use. This finding supports the theoretical framework of the Health Belief Model, which posits that perceived susceptibility is a key motivator for health-related behaviors. The strong correlation between susceptibility and concern suggests that risk perception serves as an emotional catalyst for supportive behavior, consistent with findings from other health behavior studies (r = 0.532, p = 0.00), and self-efficacy and concern (r = 0.534, p = 0.00).

The other significant correlations were

TABLE 3. Description of the Relationship Between Health Belief Attributes and Husbands' Preparedness to Support Wives' Postpartum Contraceptive Use (n = 170)

Sub-variable attributes	p-value	Correlation Coefficient (r)
Perceived susceptibility → Concern	0.00	0.548
Perceived susceptibility → Ability to facilitate	0.00	0.522
Perceived susceptibility → Appreciation	0.00	0.524
Perceived severity → Concern	0.00	0.472
Perceived severity → Ability to facilitate	0.02	0.386
Perceived severity → Appreciation	0.02	0.462
Perceived barriers → Concern	0.01	0.437
Perceived barriers → Ability to facilitate	0.00	0.487
Perceived barriers → Appreciation	0.00	0.532
Perceived benefit → Concern	0.03	0.432
Perceived benefit → Ability to facilitate	0.00	0.524
Perceived benefit → Appreciation	0.00	0.468
Self-efficacy → Concern	0.00	0.534
Self-efficacy → Ability to facilitate	0.00	0.487
Self-efficacy → Appreciation	0.02	0.421

TABLE 4. Distribution of the Relationship Between Health Beliefs and Husbands' Preparedness to Support Wives' Postpartum Contraceptive Use (n = 170)

Variable	p-value	Correlation Coefficient (r)
Husband's Health Beliefs and Preparedness	p = 0,01	r = 0,745

perceived benefit and facilitation capability (r = 0.524, p = 0.00), which suggests that husbands who were aware of the benefits of contraception were more capable of providing pragmatic support for their wives' planning choices. This relationship points to the necessity of emphasizing the positive effects of family planning in educational programs. Moreover, the correlation between perceived barriers and appreciation (r = 0.532, p = 0.00) indicates that husbands who were conscious of the barriers to contraceptive use were more likely to appreciate the effort taken by their wives in enrolling in family planning programs. It can be an indicator that if the awareness of barriers is taken into consideration, then empathy and appreciation become essential in supportive relationships. The correlation between self-efficacy and concern (r = 0.534, p = 0.00) verifies that husbands who believed in their ability to provide care to their wives were more likely to indicate concern and emotional support.

Table 4 presents the overall correlation analysis, which demonstrated a strong positive relationship between health beliefs and husband's preparedness for supporting postpartum contraceptive use (r = 0.745, p = 0.01). This robust correlation indicates that health beliefs serve as significant predictors of husbands' preparedness to support their wives' contraceptive decisions. The strength of this relationship suggests that interventions targeting health beliefs could be highly effective in improving husbands' involvement in family planning.

This study demonstrates a significant relationship between health beliefs and husbands' preparedness to support postpartum contraceptive use, with implications for family planning programs and policies. The strong positive correlation (r = 0.745, p = 0.01) aligns with previous research (Chekole *et al*., 2019; Widyastuti *et al*., 2023) that emphasizes the importance of male involvement in family planning decisions. Such interaction has been found to enable greater utilization

and continuation of contraceptive use and maternal and child health service use. That the relationship is strong is an indication that health beliefs are not only associated with readiness but can also be predictors of healthy behavior. This engagement plays a crucial role in facilitating access to maternal and child health (Davis *et al*., 2016) and overall family well-being through enhanced economic security and better health outcomes (Muntifering *et al*., 2013).

Successful couples' communication is necessary before postpartum contraception decision-making, specifically for young couples who are less experienced in making decisions on family planning (Bhattacharya *et al*., 2023; Challa *et al*., 2020; Hartmann *et al*., 2012). It has been proven that successful couples' communication on contraception results in more consistent method use and greater satisfaction with the chosen method. Since there has been a recent introduction of a new family member, the economic needs are high, which tends to impact family stability and must be well planned so that they can prepare sufficient care and resources for child development (Aslam *et al*., 2016). In countries like China, strict birth control policies impose fines that can negatively impact individual well-being and family economic status (Pan & Liu, 2021). The economic implications of family planning decisions extend beyond immediate costs to include long-term investments in child health, education, and development opportunities**.** Meanwhile, postpartum contraception allows mothers to recover physically and emotionally while providing children with the opportunity for optimal growth and development through adequate spacing between pregnancies (Mookerjee *et al*., 2023).

For this reason, the husband's preparedness behavior needs to be shown to the wife by always fully supporting the family planning program that the wife participates in after giving birth. This support is particularly important because the wife's consent to use contraception after giving birth is often contingent upon the husband's decision and approval (D'Exelle & Ringdal, 2022). Male involvement in family planning decisions can reduce the burden on women and promote shared responsibility for reproductive health outcomes**.** Positive appreciation from the husband accorded to the wife who participates in family planning programs following delivery ensures the wife is not worried or apprehensive about the program enrollment (Idris *et al.*, 2021). Psychological support matters to contraceptive continuation as women who perceive they are supported by their partners are likely to maintain contraceptive use regardless of potential side effects or challenges. Therefore, couples and families must understand, communicate, and support one another in a bid to realize mutually acceptable decisions for the benefit of maternal and child health (Underwood *et al*., 2019).

Concern, facilitation capacity, and gratitude were discovered by the research to be core features of preparedness among husbands, attesting to the complexities of supportive behavior (Owuor & Derose, 2004; Prata *et al*., 2017; Ruderman *et al*., 2022). All of these dimensions are necessary for effective participation in family planning, and they are all expressed in various forms of support: emotional support (concern), practical support (capacity to facilitate), and psychological support (appreciation). The highest correlation was found between perceived susceptibility and concern, and it was identified that husbands who are aware of the risk of unplanned pregnancies are likely to emotionally and psychologically support their wives (Sarfraz *et al*., 2023). This finding suggests that risk communication activities should focus on helping men understand the health consequences of poor birth spacing among children and mothers. However, husbands still view family planning as the responsibility of the majority of the wife, focusing on their economic provider role and not as decision-makers in reproductive health (Amuzie, Nwamoh, Ukegbu, Chukwuma, *et al*., 2022; Cheng *et al*., 2015; Gonalons-Pons & Gangl, 2021). Perceived obstacles were significantly associated with appreciation, which indicates that husbands who notice the limitations to contraception are most likely to provide support for their wives' participation in family planning programs.

This association, therefore, indicates that education on contraceptive side effects and coping strategies is actually able to increase and not diminish support because knowledge

leads to understanding and empathy. Where the husbands are conscious of the physical and psychological challenges the wives may face while using contraception, they are likely to facilitate and provide more functional assistance (Chekole *et al*., 2019). Appreciation here includes comprehension of the sacrifice and effort required in using contraception, which can strengthen the marital relationship and promote more use of family planning. Self-efficacy was also significantly related to concern, which means that husbands who trust themselves and that they can provide for their wives are more actively involved in family planning decisions and are likely to support their wives emotionally when life gets tough (D'Exelle & Ringdal, 2022). The five components of health beliefs—perceived susceptibility, perceived severity, perceived barriers, perceived benefits, and self-efficacy—are core components of Rosenstock's theoretical model (1974). Each component has a distinctive role in shaping behavior: susceptibility creates motivation, severity provides urgency, benefits supply incentives, barriers provide challenges to be overcome, and self-efficacy supplies confidence to behave.

Perceived susceptibility ranked the highest with the mean score of 3.18 ± 0.610, showing concern among husbands for unwanted pregnancies and their wives' and children's health implications. This finding is particularly relevant because perceived susceptibility is the first step of the process of altering health behavior, the driving force for action that comes next. This agrees with evidence indicating that women who do not use postpartum family planning are vulnerable to severe consequences like failure in birth spacing, maternal health complications, and negative child development (Damtie *et al*., 2021; Mookerjee *et al*., 2023). Other research indicates that perceived susceptibility plays an important role in behavior change across various health situations. When individuals feel that they are threatened with harm to their health, they will apply measures to prevent this and persuade others to take preventive measures as well (Jones *et al*., 2015).

The perceived susceptibility is an element that transcends personal risk perception to include family vulnerability, and the latter needs consideration when it comes to married men who need to consider their children's and wives' health. Create space for birth through family planning programs such that families will be able to manage their economy and allocate resources better, prioritizing the platform for achieving long-term family stability and prosperity (Canning & Schultz, 2012). Economic benefits of family planning are reduced healthcare costs, greater educational and career opportunities for women, and improved child health and educational attainment. In addition, by spacing children, they are accorded more care and a greater likelihood of healthy development, e.g., better nutrition, access to healthcare, and access to education (Chakraborty & Sprockett, 2018). While perceived benefits and perceived severity were relatively lower in correlation with preparedness dimensions, they influence husbands' preparedness and hence must be considered in the planning of interventions. Perceived severity refers to the individual's subjective estimation of the seriousness of likely health consequences, while perceived benefits refer to the good consequences of action that are expected (Rosenstock, 1974). The perceived benefits and ability relationship points toward the necessity of focusing on long-term benefits of contraception in educational programs, such as improved maternal health, child development, and financial security of the family (Prata *et al*., 2017).

Educational interventions need to establish clear, direct, and long-term benefits of family planning, including health, social, and economic advantages of the entire family. Given that family well-being is enhanced significantly by contraception through multiple avenues, a focus on the health beliefs of husbands and husband empowerment through family planning program interventions is more relevant to global reproductive health programs (Kriel *et al*., 2019). As the awareness grows that male involvement is a critical component of successful family planning programs, more research and intervention resources have been devoted to the study of men. The findings of the present study, showing a high correlation between health beliefs and husbands' preparedness ($p = 0.01$, $r = 0.745$),

strongly support this perspective and attest to the effectiveness of belief-based interventions.

This finding suggests that the effectiveness of health belief targeting programs would be greater than that of programs that are singularly focused on knowledge transfer or service provision. In addition, husbands' beliefs serve as a buffer for desirable psychological characteristics, especially regarding caring about facilitating their wives' use of contraception on a consistent and efficient basis (Sarfraz *et al*., 2023). These behaviors are paramount because husbands are more likely to hold the last word regarding family planning decisions, especially in patriarchal societies where male approval is required for health care decisions (Owuor & Derose, 2004). The findings emphasize the need for psychoeducation interventions addressing perceived self-efficacy and perceived susceptibility among husbands to improve their emotional support and active involvement in postpartum contraceptive decision-making. Counseling conducted at the community level also mitigates cultural and religious misconceptions, therefore minimizing perceived barriers and increasing appreciation for family planning (Underwood *et al*., 2019). Health care workers should also involve husbands in couple counseling sessions during antenatal care to promote improved communication and joint decision-making about postpartum contraception. Policymakers can develop supportive policies that encourage male involvement in family planning initiatives. Despite the significant findings, this study has some limitations. First, the cross-sectional design limits the ability to establish causal relationships between health beliefs and husbands' preparedness. Future research with a longitudinal approach is recommended to assess changes over time. Second, the study relied on self-reported data, which may introduce social desirability bias. Incorporating qualitative interviews could provide deeper insights into husbands' experiences and perceptions.

Conclusion

This research demonstrates significant, positive direct relationships between health beliefs and the willingness of husbands to support postpartum contraceptive use. The strongest correlations were between perceived susceptibility and concern, and self-efficacy and concern, suggesting the need for emotional support and confidence in decision-making. In addition, perceived barriers were also strongly correlated with appreciation, suggesting that husbands who are aware of the challenges of contraceptive use are more willing to show support for their wives to visit family planning programs. These findings emphasize the requirement for specific interventions that strengthen husbands' health beliefs. Enhanced psychoeducation programs focusing on increasing perceptions of susceptibility and self-efficacy can establish emotional support and active involvement of husbands in postpartum contraceptive choices. Furthermore, community-level counseling addressing cultural and religious misconceptions presents significant potential for reducing perceived barriers and fostering recognition of family planning efforts. The insights provide healthcare providers and policymakers with valuable information for designing effective strategies to promote active husband participation in postpartum family planning, thereby enhancing maternal and child health outcomes.

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KEMAS 21 (2) (2025) 321-332

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Moringa Leaves-Added Food, Baby Massage, and Tui Na Massage to Reduce Stunting Rate on Young Children in Indonesia

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Article Info

Article History:
Submitted: April 2025
Accepted: September 2025
Published: October 2025

Keywords:
diet; malnutrition; massage; moringa; stunting

DOI
https://doi.org/10.15294/kemas.v21i2.24094

Abstract

Stunting remains a significant public health issue in Indonesia, particularly in Aceh Province, where the prevalence reached 33.18% in 2021—exceeding the WHO threshold. In North Aceh District, 14.3% of children under five were stunted, with Simpang Keramat District reporting one of the highest rates (35%). This study aimed to evaluate the effectiveness of a combined intervention—Moringa leaf-supplemented food within a balanced diet, baby massage, and Tui Na massage—in improving the nutritional status of stunted children aged 0–2 years. A quasi-experimental pre-post design was used, involving 50 stunted children divided equally into treatment and control groups. The intervention was conducted over 2.5 months. Paired t-test results showed significant increases in weight ($t24 = -6.656$, $p < .000$) and height ($t24 = -3.244$, $p < .003$) in the treatment group compared to the control group. These findings suggest that combining dietary fortification using locally available Moringa leaves with physical stimulation through massage therapy can effectively enhance growth outcomes. Given the multifactorial nature of stunting, this study recommends that nurses and health practitioners incorporate both nutrition-based interventions and sensory-stimulating therapies to address growth delays in young children, particularly in high-risk areas such as Aceh.

Introduction

Demographics are more susceptible to dietary deficiencies and diseases. Toddlers are particularly vulnerable to malnutrition in terms of both body weight and height (De and Chattopadhyay, 2019; Dipasquale *et al*., 2020). The consequences of inadequate nutritional intake are multifaceted and include growth impairment. This condition is characterized by suboptimal functioning of bodily organs (Awuchi *et al*., 2020; Kiani *et al*., 2022; Setiani *et al*., 2024). Furthermore, children may exhibit compromised immunity, increasing susceptibility to various ailments, such as respiratory tract infections, diarrhea, and fever. Consequently, a physical state prone to illness may result in less qualified human resources (HR) (Sampah & Hackam, 2020; Singh *et al*., 2022; Amoadu *et al*., 2024). Stunting, defined as a failure to thrive in young children due to chronic malnutrition, results in children being shorter than expected for their age (Scheffler *et al*., 2020; Ali, 2021; Schneider, 2025). Stunting manifests as a toddler's inability to thrive due to persistent malnutrition, causing the child to be shorter than anticipated for their age. Malnutrition occurs from infancy, encompassing the prenatal and early postnatal stages; however, its effects typically become apparent when the child reaches two years of age (Morales *et al*., 2023; Najib *et al*., 2023; Tjandrawinata *et al*., 2025).

Stunting is a condition observed in children aged 0–59 months when their height-

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pISSN 1858-1196
eISSN 2355-3596

for-age falls below minus two standard deviations (<-2SD) from the World Health Organization (WHO) median criterion. This condition results in impaired brain development and adversely affects cognitive capacity (Scheffler & Hermanussen, 2022; Priyantini *et al*., 2024; Amaha, 2025). Consequently, this diminishes the potential for higher educational attainment and reduces opportunities for enhanced income prospects. Moreover, children who survive stunting exhibit a propensity towards obesity and an increased likelihood of developing non-communicable diseases (NCDs), including hypertension, diabetes, and cancer (Rachmah *et al*., 2021; Kamal, 2022; Karlsson *et al*., 2022; Naga Rajeev *et al*., 2022; Nugroho *et al*., 2023).

The stunting prevalence in Indonesia exceeds the World Health Organization (WHO) threshold by 20%, with particularly concerning rates in Aceh Province. In 2022, 148.1 million (22.3%) children under 5 years of age exhibited insufficient height for their age (stunting), 45.0 million demonstrated insufficient weight for their height (wasting), and 37.0 million (5.6%) exhibited excessive weight for their height (overweight) (WHO, 2023; Setyawati *et al*., 2024). The Indonesian Nutrition Case Study 2021 revealed that Aceh Province has the highest rate of stunting in Indonesia at 33.18% (Sakti *et al*., 2023; Fitriahadi *et al*., 2024). According to the Indonesian Ministry of National Development Planning (Bappenas) and the United Nations International Children's Emergency Fund (UNICEF) in 2018, stunted growth is attributed to chronic malnutrition throughout a child's first 1,000 days of life. Multiple factors contribute to stunting among young children, including familial and environmental factors that influence their nutritional status. Insufficient nutrient intake and recurrent illnesses result in decreased nutritional status. Consequently, environmental factors, family conditions, and behaviors that facilitate infection affect toddler nutrition. The calorie and protein per capita per day for Indonesian children appear to be significantly lower than the Recommended Nutrient Intake (RNI) for typical children and those with stunting. Persistent problems may develop if this situation continues for an extended period (Kohl *et al*., 2022; Hawa *et al*., 2024; Nyarko *et al*., 2024).

The Indonesian Central Bureau of Statistics (2023) reported that 40,762 young children in North Aceh District, 14.3% of whom exhibited stunting. This positions North Aceh as the focal point for addressing the issue of stunting in Aceh Province, particularly in three sub-districts with the highest prevalence: Langkahan (35.29%), Simpang Keramat (35%), and Baktiya (34.48%). In 2022, the North Aceh District Government expanded the scope of its stunting intervention program for young children. The program now encompasses 40 hamlets distributed among 27 sub-districts, an increase from the previous coverage of 20 villages. Healthcare professionals and community health clinics in North Aceh have implemented stunting interventions. Consequently, a novel approach or combination of interventions is necessary to enhance the height and weight of young children with stunting.

Sutrisna *et al*. (2023) concluded that children who received the Moringa leaves intervention experienced higher weight gain than the control group. In the intervention group, 80% of toddlers exhibited weight gain of ≥2 kg, while only 15% demonstrated such gain in the control group. Statistical analysis indicated that the administration of Moringa leaves effectively increases the weight of young children in Mampree Village, Syamtalira Aron District, North Aceh Regency. Moringa is a plant rich in macro and micronutrients and is commonly cultivated in Aceh. The nutrients contained in Moringa leaves have been demonstrated to enhance the growth of young children. Consumption of Moringa leaf extract aids in ameliorating poor nutrition in young children, either through incorporation into weaning foods, direct consumption, or processing into complementary foods.

Based on research conducted by Yuniastuti *et al*. (2023) in The Effect of Providing Supplementary Food Based on Moringa Leaves and Sea Fish on Serum Zinc Levels of Stunting Young Children in Sedan, Rembang Regency in 2022, a study was conducted on 30 toddlers with stunting and severe stunting nutritional status in the Sedan Community Health Center working area of the Rembang Regency. For 63

days, the toddlers were administered additional food based on moringa leaves and selfishness. Following the intervention, the zinc levels in the blood and the mean height of the toddlers increased. Additionally, a significant correlation between zinc levels and toddler height was observed, suggesting that elevated zinc levels are closely associated with increased height. Research by Sutrisna *et al*. (2023a) investigated the efficacy of developing a culture-based dietary intervention by providing moringa leaf products through fortification in treating stunted toddlers. The quasi-experimental study utilized a sample size of 50 stunted toddlers divided into two groups: 25 in the treatment group and 25 in the control group. The findings demonstrated that the height of toddlers increased following the implementation of the dietary culture development by providing moringa leaf products via fortification. On average, toddlers' height increased by 2.9 cm. Based on the results of the paired sample t-test, a significance value of 0.003 <0.05 was obtained, indicating the effectiveness of developing a dietary culture by providing moringa leaf products through fortification in addressing stunting in toddlers within the Simpang Keramat Community Health Centre Working Area.

Research conducted by Sutarmi *et al*. (2022) regarding Baby Massage Intervention as an Effort to Prevent Stunting in Toddlers demonstrated that baby massage benefits include enhanced growth (weight and body length) and development (social and motor development). Baby massage may be utilized as a nursing intervention to mitigate the risk of toddler stunting. A randomized controlled trial conducted by Erçelik and Yılmaz (2023) examined the impact of infant massage on growth parameters and maternal-infant bonding. The study involved 60 healthy term infants and their mothers, who were randomly assigned to either a massage group or a control group. The massage group received online training and performed infant massage for 20 weeks. Results showed that infants in the massage group experienced significantly greater weight gain by the eighth week ($p = 0.006$) and increased height by the twentieth week ($p = 0.05$) compared to the control group. A systematic review and meta-analysis conducted by Mollà-Casanova *et al*. (2023) evaluated the effects of massage therapy—both alone and in combination with passive mobilizations—on weight gain and the duration of hospital stay in preterm infants. The study included randomized controlled trials that compared massage therapy interventions with standard care. The findings revealed that massage therapy combined with passive mobilizations significantly improved weight gain (standardized mean difference [95% CI]: 0.67 [0.31, 1.02]) and reduced the length of hospitalization (0.53 [0.10, 0.97]) in preterm infants. However, massage therapy alone did not demonstrate a statistically significant effect on weight gain (1.14 [−0.22, 2.49]).

Ningsih and Ramadhena (2023) investigated the effect of Tui Na massage on weight gain in young children in the Karawang Regency. The study population comprised 35 respondents who underwent Tui Na massage therapy in the Rengasdengklok and Karawang Districts. Bivariate analysis was conducted to examine the effect of Tui Na massage on increasing body weight in young children. The Wilcoxon signed-rank test yielded a p-value of 0.000, indicating a statistically significant impact of Tui Na massage on body weight in young children in the Karawang Regency. These findings suggest that Tui Na massage effectively promotes weight gain in young children. This study aimed to address the prevalence of stunting in Simpang Keramat District by modifying the interventions administered to children with stunting. The revised interventions focused on enhancing nutritional status to more effectively manage young children with stunting compared to existing methods. These interventions encompassed the provision of a nutritionally balanced diet supplemented with moringa leaves and applying massage therapy and Tui Na massage therapy to stimulate appetite.

Method

This study employed a quasi-experimental design. In this investigation, young children's weight and height were measured before the intervention. The treatments administered to modify the model included the provision of moringa leaf-supplemented food in a nutritionally balanced

diet, massage therapy, and Tui Na massage therapy for appetite stimulation. The young children's height and weight gain were measured following treatment completion. The study sample comprised stunted young children. Data and measurements were obtained from participants in Simpang Keramat Village and its Community Health Center Working Area. Independent stunting management interventions were implemented in the form of control, quality, and quantity instruments by modifying weaning food treatment, traditional massage therapy, and Tui Na massage therapy to enhance appetite. The incentive provided to participants was formula milk for their children. The researcher ensured the confidentiality of the participant's data by utilizing only the initials of the participant's name on the data collection sheet, and the researcher maintained the confidentiality of the data obtained in the study by restricting access to the subject data from other parties. The interview with each participant took approximately 20 minutes to get information on local weaning foods, diet, massage therapy conducted twice a week, and tui na massage for appetite for six consecutive days, and repeated one week apart. The weight and height of all participants were re-examined in both the intervention and control groups.

The research subjects were divided into two groups: the intervention group and the control group. The intervention group was given treatment in the form of a modified model through the provision of locally based complementary foods that are more nutritious, dietary regulation, infant massage therapy, and Tui Na massage. Before the treatment, an initial measurement of the child's weight and height was carried out, which was then re-measured after 2.5 months of therapy to see the changes. Meanwhile, the control group only received the usual care generally given, namely a balanced diet without additional interventions, as in the intervention group. Weight and height measurements in the control group were carried out at the beginning of the study and again after 2.5 months to compare the results with the intervention group. Purposive sampling was used to select 50 children aged 0-2 years from Simpang Keramat Village, North Aceh District, Aceh Province, Indonesia. The sample in this study comprised 25 children with stunting in the treatment group who received moringa leaf-supplemented food in their nutritionally balanced diet, infant massage therapy, and Tui Na massage. Conversely, 25 children with stunting in the control group received only a nutritionally balanced diet. The ratio of the intervention group to the control group was 1:1.

This study utilized a comprehensive approach to address stunting issues among children at the village community level. The process commenced with a systematic effort to understand and address the nutritional challenges experienced by children. The initial stages of the study involved meticulous preparation. The research team first obtained ethical approval from the relevant institution to ensure that all research procedures adhered to the moral standards of healthcare research. Upon receiving approval, we contacted local health authorities, particularly village midwives, to identify children experiencing stunting. The research team was formed multidisciplinarily and comprised primary researchers, research assistants, community health workers, and specialized massage therapists. Before the commencement of the study, all team members underwent comprehensive training. They were instructed on child anthropometric measurement techniques, massage therapy protocols, nutritional intervention preparation, and data collection and recording methodologies.

Nutritional intervention focused on utilizing moringa leaves, renowned for their nutritional density. Moringa leaves were procured from reputable local sources and subjected to thorough cleansing, desiccation, and pulverization into a fine powder. Nutritionists subsequently incorporated moringa leaf powder into complementary pediatric foods, ensuring nutritional consistency and dietary variation. An additional critical component of this study was massage therapy. Two distinct massage modalities were administered: generalized infant massage and Tui Na therapy. Infant massage was performed bi-weekly for 2.5 months, with each session lasting approximately 20-30 minutes. Tui Na therapy was implemented intensively for six consecutive days, followed by a one-week

hiatus, and then repeated. This therapy was specifically designed to stimulate children's appetite.

The measurements were conducted with a high degree of precision. Before and following the intervention, the research team measured the children's height and weight using standardized and calibrated equipment. Each measurement was performed by trained research assistants to ensure data accuracy. Participant adherence is a critical focus. Community support groups, field study teams, and community service student groups actively monitored the continuity of the intervention. They tracked therapy attendance, daily nutritional supplement consumption, and participation in massage therapy. Throughout the study, the research team actively engaged with children with stunting and their families. This interpersonal approach not only facilitated the collection of accurate data but also fostered community trust and engagement. Research integrity principles were held in high regard. The research team was committed to maintaining data credibility, dependability, confirmability, and transferability. Every step was meticulously documented, and each observation, intervention, and change was recorded. With this comprehensive approach, the research aimed to collect data and provide tangible interventions that could address stunting problems at the community level.

Result and Discussion

The research findings were derived from a sample of 50 respondents, comprising 25 individuals in the treatment group and 25 in the control group. Respondent characteristics were categorized into four variables: young children's gender, parents' occupation, and parents' education level. In the treatment group, female children constituted the majority, accounting for 13 (52%) participants, whereas the control group was predominantly male, with 15 (60%) participants. The primary occupation among parents in both groups was fishing, with nine individuals (36%) in the treatment group and 11 (44%) in the control group engaged in this profession. Regarding parental education, both groups exhibited a similar pattern, with high school graduates forming the most significant subset, with 17 (68%) in the treatment group and 19 (76%) in the control group. A detailed overview of the participants' characteristics is presented in Table 1.

Table 1. Respondents Characteristics (n=50)

Respondents' Characteristics	Treatment Group		Control Group	
	n	%	n	%
Young children Gender				
Man	12	48	15	60
Woman	13	52	10	40
Parents' Job				
Construction Workers	6	24	7	28
Civil Servants	5	20	4	16
Fisherman	9	36	11	44
Farmer	4	16	3	12
Housewives	1	4	0	0
Parental Education				
Elementary School	1	4	2	8
Junior High School	6	24	4	16
Senior High School	17	68	19	76
Bachelor	1	4	0	0

Table 2. Comparison of Toddlers' Weight and Height Gains Before and After Given Treatments Using Paired Sample t-test (n=50)

Characteristics	Mean	Std Deviation	t	P value*
Treatment Group				
Weight Before (kg)	11,160	1,3904	-6,656	0,000
Weight After (kg)	11,640	1,4347		
Height Before (cm)	87,192	7,3644	-3,244	0,003
Height After (cm)	90,028	7,4700		
Non-Treatment Group				
Weight Before (kg)	9,608	1,6894	0,989	0,332
Weight After (kg)	9,432	1,5771		
Height Before (cm)	79,012	13,5747	-1,159	0,258
Height After (cm)	81,052	8,5675		

* Paired t-test

Based on the results of research conducted by analysis, several examinations revealed that the number of participants utilized in this study was 50 stunted young children residing within the Simpang Keramat Community Health Center Working area. The sample was divided into a treatment group of 25 stunted young children and a control group of 25 stunted young children. The samples in this study were then examined for several characteristics, including sex, occupation, and parental education level. The majority of participants in the treatment group were young female children, comprising 13 stunted young children (52%). Conversely, 15 young male children (60%) were included in the control group (Table 1).

Regarding the occupational characteristics of the parents, the majority of parents in the treatment group, 9 individuals (36%), were employed as fishermen. Similarly, the majority in the control group, 11 individuals (44%), were also used as fishermen. Characteristics of the parents' educational level indicated that high school graduates constituted the majority in the treatment group (17 or 68%) and the control group (19 or 76%). Based on the results of the bivariate analysis, it was found that among the 50 samples, there was a significant difference before and after the experimental period between the stunted young children in the treatment and control groups. In the treatment group, young children's body weight before intervention had a mean value of 11.160 kg, and after intervention had a mean value of 11.640 kg. Thus, the difference in mean body weight before and after intervention was 0.48 kg. This indicates that there was weight gain in stunted young children in the treatment group. In the control group, the mean body weight of the stunted young children was 9.608 kg. Their body weight after 2.5 months was measured again and had a mean value of 9.432 kg. Thus, the difference in mean body weight before and after the experiment was -0.176 kg. This indicated a decrease in body weight of 0.176 kg in the stunted young children in the control group (Table 2).

Regarding body height, before applying the interventions to stunted young children, the mean height was 87.192 cm. Following treatment, the mean height of the stunted young children was 90.028 cm. Consequently, the difference in the mean height before and after treatment was 2.836 cm. This indicates that the treatments resulted in an increase in height among the stunted young children. In the control group, the mean initial height of previously stunted young children was 79.012 cm. After a 2.5-month observation period without any interventions administered to this group, the mean height of the young children was 81.052 cm. However, the difference in mean height before and after the 2.5-month

period was 2.04 cm, representing only a modest height gain (Table 2).

The nutritional status of young children improved following the interventions, as evidenced by post-treatment increases in weight and height among stunted young children. Specifically, stunted young children exhibited measurable gains in weight and height after the interventions compared to their pre-treatment measurements. On average, the weight of young children increased by 0.48 kg, while the mean height of young children post-intervention increased by 2.836 cm. The interventions administered to the stunted young children comprise nutritionally enhanced weaning foods (moringa leaves combined with local foods), infant massage, and Tui Na massage therapy, which are recognized to stimulate appetite in young children and demonstrate efficacy in enhancing eating behavior and physical development, thereby improving the nutritional status of stunted young children. In the non-intervention group of stunted young children, after 2.5 months, the toddlers' height increased marginally by 2.04 cm, while their weight decreased by 0.176 kg (Table 2).

The study results found that in the Treatment Group, the output of pair 1 produced a significance value of 0.000 (sig. < 0.05). As a result, it can be concluded that there is a statistically significant difference between the weight of young children before and after the treatment given in developing a model for stunting management through the provision of local complementary foods, infant massage, and Tui Na massage therapy to increase appetite. Furthermore, the output of pair 2 produced a significant value of 0.006 (sig. < 0.05), which indicates a statistically significant difference between the height of toddlers before and after the treatment given in developing a model for stunting management. This model combines local complementary foods, eating habits, infant massage, and Tui Na massage therapy for appetite stimulation (Table 2). In the Non-Treatment Group, the output of pair 3 produced a significant value of 0.332 (sig. > 0.05), indicating no statistically significant difference in toddler weight before and after 2.5 months. In addition, the output of Pair 4 produced an essential value of 0.258 (sig. > 0.05), indicating no statistically significant difference in toddler height before and after 2.5 months. The significance values (2-tailed) obtained were 0.000 and 0.003, both < 0.05. This indicates a significant influence on the experimental group that received treatment to develop a stunting management model, which includes local food-based complementary foods, eating habits, infant massage therapy, and Tui Na massage for appetite stimulation (Table 2).

Conversely, the control group, which did not receive any treatment, demonstrated no significant effect. Given these findings, it can be concluded that there is a substantial effect of providing complementary foods based on local food culture, diet, dietary habits, massage, and Tui Na massage for appetite stimulation in improving the nutritional status of stunted young children in the Simpang Keramat Community Health Center Working Area. Consequently, the Ha hypothesis was accepted, and the H0 hypothesis was rejected. The results of this research are corroborated by a study conducted by Fathnur *et al.* in 2019, which reported that moringa leaf pudding potentially increased the weight of undernourished young children by 100% in 17 intervention group respondents over three weeks, with a p-value of 0.039. Additionally, a study conducted by Hartina in 2022 found a p-value of 0.000 < 0.05, indicating a significant effect of moringa leaf extract on the nutritional status of young children, as measured by body weight and height (Table 2).

Lolan and Fauzia's research in 2023 demonstrated that local foods and parenting patterns influence the prevalence of stunting in young children aged 6-24 months in Bandung. The study employed a purposive sampling method, which revealed that fathers' education significantly affected stunting status, with a p-value of 0.034. Local food provision significantly influenced stunting in young children, with a p-value of 0.022 (p-value <0.05). Parenting patterns significantly affected stunting, with a p-value of 0.001 ($p < 0.05$). It can be concluded that the risk factors for stunting in young children are the father's education level, local food processing, and parenting patterns related to nutritious food. Fauziah and Krianto (2022) elucidated in their review the influence of

local food culture in preventing and addressing stunting in children under five years of age (6-59 months): Systematic Review. The findings from the review of seven selected journals indicate that local food culture improves the nutritional status of children under five years of age, particularly in the stunting prevention phase. However, in the prevention phase, local food culture utilizing processed food has not demonstrated efficacy in improving the nutritional status of young children already affected by stunting. Utilizing local food for young children suffering from stunting necessitates supplementation with other nutrients to yield a significant impact. Food and eating practices within communities possess cultural and social values; therefore, leveraging local food culture for young children's nutrition is accepted, readily accessible, and affordable for stunting prevention in specific regions.

Research by Diana *et al*. (2022) shows that the concept of eating and the perception of the Madurese community in Sampang Regency affect children's eating behavior and the incidence of stunting. Many parents consider short stature a hereditary factor, not a growth problem, as long as the child is active and wants to eat, which in their culture means eating rice. An unbalanced diet is considered harmless. Children with normal height tend to consume more varied foods than stunted children, who generally only eat rice with vegetable soup or fish broth without additional side dishes. This study emphasizes raising awareness about stunting and encouraging a more varied diet for children, not just relying on rice. Research about the development and optimization of cactus pear fruit jelly supplemented with Moringa oleifera leaf extract results indicated a significant difference in protein, fat, fiber, ash, carbohydrate, energy, iron, calcium, zinc, appearance, aroma, and taste among the formulated jellies ($p < 0.05$). The overall optimum nutritional and sensorial attributes of the jelly were found in a range of CFJ (70–73%), MOE (3–14%), and TS (20–26%). However, developing jelly with the formulation of CFJ (68 %), MOE (12%), and TS (20%) was predicted to give the highest nutritional value and sensory acceptability score (Akelom *et al*., 2022).

A study conducted in Benin by Founmilayo *et al*. (2023) involved 150 children aged 12–59 months with moderate acute malnutrition. The intervention group received porridge enriched with moringa leaf flour five times per week for six months. The results showed an average weight gain of 1.72 kg ($p < 0.005$) and a 10.42% reduction in the prevalence of acute malnutrition ($p < 0.005$) compared to the control group, which received only nutrition education. These findings are consistent with a study by Zongo (2018) in Burkina Faso, which reported that consuming moringa leaf powder for 12 weeks improved the nutritional status of preschool children, as indicated by increases in weight-for-height Z-scores (WHZ) and serum retinol concentrations. The nutrients contained in moringa leaves have been proven to promote child growth. Consumption of unhealthy snacks or 'junk' food poses a serious risk to a child's nutritional status. Moringa oleifera was selected for snack development because it is nutrient-rich (Zeeshan *et al*., 2024; Arshad *et al*. 2025). The survey showed that 87% of the caregivers gave children snacks daily. The snacks commonly given to children were savory (73%), fruity (53%), dairy (46%), and sugary (43%) types. The snacks containing 1% MOLP were almost as acceptable as the control regarding all sensory attributes evaluated, including overall acceptability. They had higher calcium, magnesium, potassium, phosphorus, zinc, manganese, iron, and crude protein concentrations but less fat than the control. The results indicate that snacks supplemented with MOLP can improve children's food and nutrition security status among vulnerable population groups (Olusanya *et al*., 2020).

Young children require adequate nutrition owing to their rapid growth and development, particularly during the first two years of life (Marshall *et al*., 2022). This accelerated growth and development period necessitates parental attention and the provision of nourished food for young children. Prolonged insufficient nutrient intake may lead to chronic energy deficiency (CED) (Yuliastanti *et al*., 2023). Conversely, optimal nutritional and health status can be achieved when the body receives and efficiently utilizes sufficient dietary intake (Mousa *et al*., 2019). Meanwhile, Sutarmi *et al*. (2022) investigated

the efficacy of healthy massage on the growth and development of stunting infants. The study revealed a statistically significant enhancement in personal social development (p=0.03) compared to the control group. Additionally, anthropometric measurements significantly improved upper arm circumference (p=0.000) and body length (p=0.019). Consequently, the findings suggest that healthy massage constitutes an efficacious intervention for ameliorating the growth and development of stunted infants.

The research conducted by Maulida *et al*. (2024) on the effect of Tui Na Massage on the growth of stunted young children revealed a difference in the average body weight of 0.18 (180 grams) and body height of 1.15 cm before and after the administration of Tui Na Massage. The statistical test results yielded a p-value of 0.012 (p<0.05), indicating a significant effect of Tui Na Massage on increasing the weight of stunted young children. Furthermore, the study demonstrated an effect of Tu ina Massage on increasing height, with a p-value of 0.003 (p<0.05). These findings suggest that Tui Na Massage may be considered an alternative therapy for preventing and treating stunting in young children. Rangkuti (2022) conducted research on the effectiveness of tui na massage in increasing appetite in young children who experienced difficulty eating. The results demonstrated a p-value of 0.0000, suggesting that tui na massage was efficacious in enhancing appetite in young children in Medan City. The findings indicated that consistent application of tui na massage correlates positively with increased appetite in toddlers. It is recommended that mothers of young children implement this massage technique regularly.

Conclusion

The research concluded that there was a statistically significant difference between the treatment group and the non-treatment group regarding implementing a developed model of stunting management in young children. Furthermore, the study demonstrated a substantial impact of administering local weaning foods, baby massage therapy, and Tui Na massage therapy on stunted young children, as evidenced by increased body weight and height in the treatment group. Conversely, no significant difference was observed in the body weight and height of the stunted young children before and after the experiment in the non-treatment (control) group. The researchers extend their sincere appreciation to Bumi Persada University for supporting the implementation of this study and for providing funding assistance for the publication of this research.

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KEMAS 21 (2) (2025) 321-332

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Moringa Leaves-Added Food, Baby Massage, and Tui Na Massage to Reduce Stunting Rate on Young Children in Indonesia

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Article Info

Article History:
Submitted: April 2025
Accepted: September 2025
Published: October 2025

Keywords:
diet; malnutrition; massage; moringa; stunting

DOI
https://doi.org/10.15294/kemas.v21i2.24094

Abstract

Stunting remains a significant public health issue in Indonesia, particularly in Aceh Province, where the prevalence reached 33.18% in 2021—exceeding the WHO threshold. In North Aceh District, 14.3% of children under five were stunted, with Simpang Keramat District reporting one of the highest rates (35%). This study aimed to evaluate the effectiveness of a combined intervention—Moringa leaf-supplemented food within a balanced diet, baby massage, and Tui Na massage—in improving the nutritional status of stunted children aged 0–2 years. A quasi-experimental pre-post design was used, involving 50 stunted children divided equally into treatment and control groups. The intervention was conducted over 2.5 months. Paired t-test results showed significant increases in weight ($t24 = -6.656$, $p < .000$) and height ($t24 = -3.244$, $p < .003$) in the treatment group compared to the control group. These findings suggest that combining dietary fortification using locally available Moringa leaves with physical stimulation through massage therapy can effectively enhance growth outcomes. Given the multifactorial nature of stunting, this study recommends that nurses and health practitioners incorporate both nutrition-based interventions and sensory-stimulating therapies to address growth delays in young children, particularly in high-risk areas such as Aceh.

Introduction

Demographics are more susceptible to dietary deficiencies and diseases. Toddlers are particularly vulnerable to malnutrition in terms of both body weight and height (De and Chattopadhyay, 2019; Dipasquale *et al*., 2020). The consequences of inadequate nutritional intake are multifaceted and include growth impairment. This condition is characterized by suboptimal functioning of bodily organs (Awuchi *et al*., 2020; Kiani *et al*., 2022; Setiani *et al*., 2024). Furthermore, children may exhibit compromised immunity, increasing susceptibility to various ailments, such as respiratory tract infections, diarrhea, and fever. Consequently, a physical state prone to illness may result in less qualified human resources (HR) (Sampah & Hackam, 2020; Singh *et al*., 2022; Amoadu *et al*., 2024). Stunting, defined as a failure to thrive in young children due to chronic malnutrition, results in children being shorter than expected for their age (Scheffler *et al*., 2020; Ali, 2021; Schneider, 2025). Stunting manifests as a toddler's inability to thrive due to persistent malnutrition, causing the child to be shorter than anticipated for their age. Malnutrition occurs from infancy, encompassing the prenatal and early postnatal stages; however, its effects typically become apparent when the child reaches two years of age (Morales *et al*., 2023; Najib *et al*., 2023; Tjandrawinata *et al*., 2025).

Stunting is a condition observed in children aged 0–59 months when their height-

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pISSN 1858-1196
eISSN 2355-3596

for-age falls below minus two standard deviations (<-2SD) from the World Health Organization (WHO) median criterion. This condition results in impaired brain development and adversely affects cognitive capacity (Scheffler & Hermanussen, 2022; Priyantini *et al*., 2024; Amaha, 2025). Consequently, this diminishes the potential for higher educational attainment and reduces opportunities for enhanced income prospects. Moreover, children who survive stunting exhibit a propensity towards obesity and an increased likelihood of developing non-communicable diseases (NCDs), including hypertension, diabetes, and cancer (Rachmah *et al*., 2021; Kamal, 2022; Karlsson *et al*., 2022; Naga Rajeev *et al*., 2022; Nugroho *et al*., 2023).

The stunting prevalence in Indonesia exceeds the World Health Organization (WHO) threshold by 20%, with particularly concerning rates in Aceh Province. In 2022, 148.1 million (22.3%) children under 5 years of age exhibited insufficient height for their age (stunting), 45.0 million demonstrated insufficient weight for their height (wasting), and 37.0 million (5.6%) exhibited excessive weight for their height (overweight) (WHO, 2023; Setyawati *et al*., 2024). The Indonesian Nutrition Case Study 2021 revealed that Aceh Province has the highest rate of stunting in Indonesia at 33.18% (Sakti *et al*., 2023; Fitriahadi *et al*., 2024). According to the Indonesian Ministry of National Development Planning (Bappenas) and the United Nations International Children's Emergency Fund (UNICEF) in 2018, stunted growth is attributed to chronic malnutrition throughout a child's first 1,000 days of life. Multiple factors contribute to stunting among young children, including familial and environmental factors that influence their nutritional status. Insufficient nutrient intake and recurrent illnesses result in decreased nutritional status. Consequently, environmental factors, family conditions, and behaviors that facilitate infection affect toddler nutrition. The calorie and protein per capita per day for Indonesian children appear to be significantly lower than the Recommended Nutrient Intake (RNI) for typical children and those with stunting. Persistent problems may develop if this situation continues for an extended period (Kohl *et al*., 2022; Hawa *et al*., 2024; Nyarko *et al*., 2024).

The Indonesian Central Bureau of Statistics (2023) reported that 40,762 young children in North Aceh District, 14.3% of whom exhibited stunting. This positions North Aceh as the focal point for addressing the issue of stunting in Aceh Province, particularly in three sub-districts with the highest prevalence: Langkahan (35.29%), Simpang Keramat (35%), and Baktiya (34.48%). In 2022, the North Aceh District Government expanded the scope of its stunting intervention program for young children. The program now encompasses 40 hamlets distributed among 27 sub-districts, an increase from the previous coverage of 20 villages. Healthcare professionals and community health clinics in North Aceh have implemented stunting interventions. Consequently, a novel approach or combination of interventions is necessary to enhance the height and weight of young children with stunting.

Sutrisna *et al*. (2023) concluded that children who received the Moringa leaves intervention experienced higher weight gain than the control group. In the intervention group, 80% of toddlers exhibited weight gain of ≥2 kg, while only 15% demonstrated such gain in the control group. Statistical analysis indicated that the administration of Moringa leaves effectively increases the weight of young children in Mampree Village, Syamtalira Aron District, North Aceh Regency. Moringa is a plant rich in macro and micronutrients and is commonly cultivated in Aceh. The nutrients contained in Moringa leaves have been demonstrated to enhance the growth of young children. Consumption of Moringa leaf extract aids in ameliorating poor nutrition in young children, either through incorporation into weaning foods, direct consumption, or processing into complementary foods.

Based on research conducted by Yuniastuti *et al*. (2023) in The Effect of Providing Supplementary Food Based on Moringa Leaves and Sea Fish on Serum Zinc Levels of Stunting Young Children in Sedan, Rembang Regency in 2022, a study was conducted on 30 toddlers with stunting and severe stunting nutritional status in the Sedan Community Health Center working area of the Rembang Regency. For 63

days, the toddlers were administered additional food based on moringa leaves and selfishness. Following the intervention, the zinc levels in the blood and the mean height of the toddlers increased. Additionally, a significant correlation between zinc levels and toddler height was observed, suggesting that elevated zinc levels are closely associated with increased height. Research by Sutrisna *et al*. (2023a) investigated the efficacy of developing a culture-based dietary intervention by providing moringa leaf products through fortification in treating stunted toddlers. The quasi-experimental study utilized a sample size of 50 stunted toddlers divided into two groups: 25 in the treatment group and 25 in the control group. The findings demonstrated that the height of toddlers increased following the implementation of the dietary culture development by providing moringa leaf products via fortification. On average, toddlers' height increased by 2.9 cm. Based on the results of the paired sample t-test, a significance value of 0.003 <0.05 was obtained, indicating the effectiveness of developing a dietary culture by providing moringa leaf products through fortification in addressing stunting in toddlers within the Simpang Keramat Community Health Centre Working Area.

Research conducted by Sutarmi *et al*. (2022) regarding Baby Massage Intervention as an Effort to Prevent Stunting in Toddlers demonstrated that baby massage benefits include enhanced growth (weight and body length) and development (social and motor development). Baby massage may be utilized as a nursing intervention to mitigate the risk of toddler stunting. A randomized controlled trial conducted by Erçelik and Yılmaz (2023) examined the impact of infant massage on growth parameters and maternal-infant bonding. The study involved 60 healthy term infants and their mothers, who were randomly assigned to either a massage group or a control group. The massage group received online training and performed infant massage for 20 weeks. Results showed that infants in the massage group experienced significantly greater weight gain by the eighth week ($p = 0.006$) and increased height by the twentieth week ($p = 0.05$) compared to the control group. A systematic review and meta-analysis conducted by Mollà-Casanova *et al*. (2023) evaluated the effects of massage therapy—both alone and in combination with passive mobilizations—on weight gain and the duration of hospital stay in preterm infants. The study included randomized controlled trials that compared massage therapy interventions with standard care. The findings revealed that massage therapy combined with passive mobilizations significantly improved weight gain (standardized mean difference [95% CI]: 0.67 [0.31, 1.02]) and reduced the length of hospitalization (0.53 [0.10, 0.97]) in preterm infants. However, massage therapy alone did not demonstrate a statistically significant effect on weight gain (1.14 [−0.22, 2.49]).

Ningsih and Ramadhena (2023) investigated the effect of Tui Na massage on weight gain in young children in the Karawang Regency. The study population comprised 35 respondents who underwent Tui Na massage therapy in the Rengasdengklok and Karawang Districts. Bivariate analysis was conducted to examine the effect of Tui Na massage on increasing body weight in young children. The Wilcoxon signed-rank test yielded a p-value of 0.000, indicating a statistically significant impact of Tui Na massage on body weight in young children in the Karawang Regency. These findings suggest that Tui Na massage effectively promotes weight gain in young children. This study aimed to address the prevalence of stunting in Simpang Keramat District by modifying the interventions administered to children with stunting. The revised interventions focused on enhancing nutritional status to more effectively manage young children with stunting compared to existing methods. These interventions encompassed the provision of a nutritionally balanced diet supplemented with moringa leaves and applying massage therapy and Tui Na massage therapy to stimulate appetite.

Method

This study employed a quasi-experimental design. In this investigation, young children's weight and height were measured before the intervention. The treatments administered to modify the model included the provision of moringa leaf-supplemented food in a nutritionally balanced

diet, massage therapy, and Tui Na massage therapy for appetite stimulation. The young children's height and weight gain were measured following treatment completion. The study sample comprised stunted young children. Data and measurements were obtained from participants in Simpang Keramat Village and its Community Health Center Working Area. Independent stunting management interventions were implemented in the form of control, quality, and quantity instruments by modifying weaning food treatment, traditional massage therapy, and Tui Na massage therapy to enhance appetite. The incentive provided to participants was formula milk for their children. The researcher ensured the confidentiality of the participant's data by utilizing only the initials of the participant's name on the data collection sheet, and the researcher maintained the confidentiality of the data obtained in the study by restricting access to the subject data from other parties. The interview with each participant took approximately 20 minutes to get information on local weaning foods, diet, massage therapy conducted twice a week, and tui na massage for appetite for six consecutive days, and repeated one week apart. The weight and height of all participants were re-examined in both the intervention and control groups.

The research subjects were divided into two groups: the intervention group and the control group. The intervention group was given treatment in the form of a modified model through the provision of locally based complementary foods that are more nutritious, dietary regulation, infant massage therapy, and Tui Na massage. Before the treatment, an initial measurement of the child's weight and height was carried out, which was then re-measured after 2.5 months of therapy to see the changes. Meanwhile, the control group only received the usual care generally given, namely a balanced diet without additional interventions, as in the intervention group. Weight and height measurements in the control group were carried out at the beginning of the study and again after 2.5 months to compare the results with the intervention group. Purposive sampling was used to select 50 children aged 0-2 years from Simpang Keramat Village, North Aceh District, Aceh Province, Indonesia. The sample in this study comprised 25 children with stunting in the treatment group who received moringa leaf-supplemented food in their nutritionally balanced diet, infant massage therapy, and Tui Na massage. Conversely, 25 children with stunting in the control group received only a nutritionally balanced diet. The ratio of the intervention group to the control group was 1:1.

This study utilized a comprehensive approach to address stunting issues among children at the village community level. The process commenced with a systematic effort to understand and address the nutritional challenges experienced by children. The initial stages of the study involved meticulous preparation. The research team first obtained ethical approval from the relevant institution to ensure that all research procedures adhered to the moral standards of healthcare research. Upon receiving approval, we contacted local health authorities, particularly village midwives, to identify children experiencing stunting. The research team was formed multidisciplinarily and comprised primary researchers, research assistants, community health workers, and specialized massage therapists. Before the commencement of the study, all team members underwent comprehensive training. They were instructed on child anthropometric measurement techniques, massage therapy protocols, nutritional intervention preparation, and data collection and recording methodologies.

Nutritional intervention focused on utilizing moringa leaves, renowned for their nutritional density. Moringa leaves were procured from reputable local sources and subjected to thorough cleansing, desiccation, and pulverization into a fine powder. Nutritionists subsequently incorporated moringa leaf powder into complementary pediatric foods, ensuring nutritional consistency and dietary variation. An additional critical component of this study was massage therapy. Two distinct massage modalities were administered: generalized infant massage and Tui Na therapy. Infant massage was performed bi-weekly for 2.5 months, with each session lasting approximately 20-30 minutes. Tui Na therapy was implemented intensively for six consecutive days, followed by a one-week

hiatus, and then repeated. This therapy was specifically designed to stimulate children's appetite.

The measurements were conducted with a high degree of precision. Before and following the intervention, the research team measured the children's height and weight using standardized and calibrated equipment. Each measurement was performed by trained research assistants to ensure data accuracy. Participant adherence is a critical focus. Community support groups, field study teams, and community service student groups actively monitored the continuity of the intervention. They tracked therapy attendance, daily nutritional supplement consumption, and participation in massage therapy. Throughout the study, the research team actively engaged with children with stunting and their families. This interpersonal approach not only facilitated the collection of accurate data but also fostered community trust and engagement. Research integrity principles were held in high regard. The research team was committed to maintaining data credibility, dependability, confirmability, and transferability. Every step was meticulously documented, and each observation, intervention, and change was recorded. With this comprehensive approach, the research aimed to collect data and provide tangible interventions that could address stunting problems at the community level.

Result and Discussion

The research findings were derived from a sample of 50 respondents, comprising 25 individuals in the treatment group and 25 in the control group. Respondent characteristics were categorized into four variables: young children's gender, parents' occupation, and parents' education level. In the treatment group, female children constituted the majority, accounting for 13 (52%) participants, whereas the control group was predominantly male, with 15 (60%) participants. The primary occupation among parents in both groups was fishing, with nine individuals (36%) in the treatment group and 11 (44%) in the control group engaged in this profession. Regarding parental education, both groups exhibited a similar pattern, with high school graduates forming the most significant subset, with 17 (68%) in the treatment group and 19 (76%) in the control group. A detailed overview of the participants' characteristics is presented in Table 1.

Table 1. Respondents Characteristics (n=50)

Respondents' Characteristics	Treatment Group		Control Group	
	n	%	n	%
Young children Gender				
Man	12	48	15	60
Woman	13	52	10	40
Parents' Job				
Construction Workers	6	24	7	28
Civil Servants	5	20	4	16
Fisherman	9	36	11	44
Farmer	4	16	3	12
Housewives	1	4	0	0
Parental Education				
Elementary School	1	4	2	8
Junior High School	6	24	4	16
Senior High School	17	68	19	76
Bachelor	1	4	0	0

Table 2. Comparison of Toddlers' Weight and Height Gains Before and After Given Treatments Using Paired Sample t-test (n=50)

Characteristics	Mean	Std Deviation	t	P value*
Treatment Group				
Weight Before (kg)	11,160	1,3904	-6,656	0,000
Weight After (kg)	11,640	1,4347		
Height Before (cm)	87,192	7,3644	-3,244	0,003
Height After (cm)	90,028	7,4700		
Non-Treatment Group				
Weight Before (kg)	9,608	1,6894	0,989	0,332
Weight After (kg)	9,432	1,5771		
Height Before (cm)	79,012	13,5747	-1,159	0,258
Height After (cm)	81,052	8,5675		

* Paired t-test

Based on the results of research conducted by analysis, several examinations revealed that the number of participants utilized in this study was 50 stunted young children residing within the Simpang Keramat Community Health Center Working area. The sample was divided into a treatment group of 25 stunted young children and a control group of 25 stunted young children. The samples in this study were then examined for several characteristics, including sex, occupation, and parental education level. The majority of participants in the treatment group were young female children, comprising 13 stunted young children (52%). Conversely, 15 young male children (60%) were included in the control group (Table 1).

Regarding the occupational characteristics of the parents, the majority of parents in the treatment group, 9 individuals (36%), were employed as fishermen. Similarly, the majority in the control group, 11 individuals (44%), were also used as fishermen. Characteristics of the parents' educational level indicated that high school graduates constituted the majority in the treatment group (17 or 68%) and the control group (19 or 76%). Based on the results of the bivariate analysis, it was found that among the 50 samples, there was a significant difference before and after the experimental period between the stunted young children in the treatment and control groups. In the treatment group, young children's body weight before intervention had a mean value of 11.160 kg, and after intervention had a mean value of 11.640 kg. Thus, the difference in mean body weight before and after intervention was 0.48 kg. This indicates that there was weight gain in stunted young children in the treatment group. In the control group, the mean body weight of the stunted young children was 9.608 kg. Their body weight after 2.5 months was measured again and had a mean value of 9.432 kg. Thus, the difference in mean body weight before and after the experiment was -0.176 kg. This indicated a decrease in body weight of 0.176 kg in the stunted young children in the control group (Table 2).

Regarding body height, before applying the interventions to stunted young children, the mean height was 87.192 cm. Following treatment, the mean height of the stunted young children was 90.028 cm. Consequently, the difference in the mean height before and after treatment was 2.836 cm. This indicates that the treatments resulted in an increase in height among the stunted young children. In the control group, the mean initial height of previously stunted young children was 79.012 cm. After a 2.5-month observation period without any interventions administered to this group, the mean height of the young children was 81.052 cm. However, the difference in mean height before and after the 2.5-month

period was 2.04 cm, representing only a modest height gain (Table 2).

The nutritional status of young children improved following the interventions, as evidenced by post-treatment increases in weight and height among stunted young children. Specifically, stunted young children exhibited measurable gains in weight and height after the interventions compared to their pre-treatment measurements. On average, the weight of young children increased by 0.48 kg, while the mean height of young children post-intervention increased by 2.836 cm. The interventions administered to the stunted young children comprise nutritionally enhanced weaning foods (moringa leaves combined with local foods), infant massage, and Tui Na massage therapy, which are recognized to stimulate appetite in young children and demonstrate efficacy in enhancing eating behavior and physical development, thereby improving the nutritional status of stunted young children. In the non-intervention group of stunted young children, after 2.5 months, the toddlers' height increased marginally by 2.04 cm, while their weight decreased by 0.176 kg (Table 2).

The study results found that in the Treatment Group, the output of pair 1 produced a significance value of 0.000 (sig. < 0.05). As a result, it can be concluded that there is a statistically significant difference between the weight of young children before and after the treatment given in developing a model for stunting management through the provision of local complementary foods, infant massage, and Tui Na massage therapy to increase appetite. Furthermore, the output of pair 2 produced a significant value of 0.006 (sig. < 0.05), which indicates a statistically significant difference between the height of toddlers before and after the treatment given in developing a model for stunting management. This model combines local complementary foods, eating habits, infant massage, and Tui Na massage therapy for appetite stimulation (Table 2). In the Non-Treatment Group, the output of pair 3 produced a significant value of 0.332 (sig. > 0.05), indicating no statistically significant difference in toddler weight before and after 2.5 months. In addition, the output of Pair 4 produced an essential value of 0.258 (sig. > 0.05), indicating no statistically significant difference in toddler height before and after 2.5 months. The significance values (2-tailed) obtained were 0.000 and 0.003, both < 0.05. This indicates a significant influence on the experimental group that received treatment to develop a stunting management model, which includes local food-based complementary foods, eating habits, infant massage therapy, and Tui Na massage for appetite stimulation (Table 2).

Conversely, the control group, which did not receive any treatment, demonstrated no significant effect. Given these findings, it can be concluded that there is a substantial effect of providing complementary foods based on local food culture, diet, dietary habits, massage, and Tui Na massage for appetite stimulation in improving the nutritional status of stunted young children in the Simpang Keramat Community Health Center Working Area. Consequently, the Ha hypothesis was accepted, and the H0 hypothesis was rejected. The results of this research are corroborated by a study conducted by Fathnur *et al.* in 2019, which reported that moringa leaf pudding potentially increased the weight of undernourished young children by 100% in 17 intervention group respondents over three weeks, with a p-value of 0.039. Additionally, a study conducted by Hartina in 2022 found a p-value of 0.000 < 0.05, indicating a significant effect of moringa leaf extract on the nutritional status of young children, as measured by body weight and height (Table 2).

Lolan and Fauzia's research in 2023 demonstrated that local foods and parenting patterns influence the prevalence of stunting in young children aged 6-24 months in Bandung. The study employed a purposive sampling method, which revealed that fathers' education significantly affected stunting status, with a p-value of 0.034. Local food provision significantly influenced stunting in young children, with a p-value of 0.022 (p-value <0.05). Parenting patterns significantly affected stunting, with a p-value of 0.001 ($p < 0.05$). It can be concluded that the risk factors for stunting in young children are the father's education level, local food processing, and parenting patterns related to nutritious food. Fauziah and Krianto (2022) elucidated in their review the influence of

local food culture in preventing and addressing stunting in children under five years of age (6-59 months): Systematic Review. The findings from the review of seven selected journals indicate that local food culture improves the nutritional status of children under five years of age, particularly in the stunting prevention phase. However, in the prevention phase, local food culture utilizing processed food has not demonstrated efficacy in improving the nutritional status of young children already affected by stunting. Utilizing local food for young children suffering from stunting necessitates supplementation with other nutrients to yield a significant impact. Food and eating practices within communities possess cultural and social values; therefore, leveraging local food culture for young children's nutrition is accepted, readily accessible, and affordable for stunting prevention in specific regions.

Research by Diana *et al*. (2022) shows that the concept of eating and the perception of the Madurese community in Sampang Regency affect children's eating behavior and the incidence of stunting. Many parents consider short stature a hereditary factor, not a growth problem, as long as the child is active and wants to eat, which in their culture means eating rice. An unbalanced diet is considered harmless. Children with normal height tend to consume more varied foods than stunted children, who generally only eat rice with vegetable soup or fish broth without additional side dishes. This study emphasizes raising awareness about stunting and encouraging a more varied diet for children, not just relying on rice. Research about the development and optimization of cactus pear fruit jelly supplemented with Moringa oleifera leaf extract results indicated a significant difference in protein, fat, fiber, ash, carbohydrate, energy, iron, calcium, zinc, appearance, aroma, and taste among the formulated jellies ($p < 0.05$). The overall optimum nutritional and sensorial attributes of the jelly were found in a range of CFJ (70–73%), MOE (3–14%), and TS (20–26%). However, developing jelly with the formulation of CFJ (68 %), MOE (12%), and TS (20%) was predicted to give the highest nutritional value and sensory acceptability score (Akelom *et al*., 2022).

A study conducted in Benin by Founmilayo *et al*. (2023) involved 150 children aged 12–59 months with moderate acute malnutrition. The intervention group received porridge enriched with moringa leaf flour five times per week for six months. The results showed an average weight gain of 1.72 kg ($p < 0.005$) and a 10.42% reduction in the prevalence of acute malnutrition ($p < 0.005$) compared to the control group, which received only nutrition education. These findings are consistent with a study by Zongo (2018) in Burkina Faso, which reported that consuming moringa leaf powder for 12 weeks improved the nutritional status of preschool children, as indicated by increases in weight-for-height Z-scores (WHZ) and serum retinol concentrations. The nutrients contained in moringa leaves have been proven to promote child growth. Consumption of unhealthy snacks or 'junk' food poses a serious risk to a child's nutritional status. Moringa oleifera was selected for snack development because it is nutrient-rich (Zeeshan *et al*., 2024; Arshad *et al*. 2025). The survey showed that 87% of the caregivers gave children snacks daily. The snacks commonly given to children were savory (73%), fruity (53%), dairy (46%), and sugary (43%) types. The snacks containing 1% MOLP were almost as acceptable as the control regarding all sensory attributes evaluated, including overall acceptability. They had higher calcium, magnesium, potassium, phosphorus, zinc, manganese, iron, and crude protein concentrations but less fat than the control. The results indicate that snacks supplemented with MOLP can improve children's food and nutrition security status among vulnerable population groups (Olusanya *et al*., 2020).

Young children require adequate nutrition owing to their rapid growth and development, particularly during the first two years of life (Marshall *et al*., 2022). This accelerated growth and development period necessitates parental attention and the provision of nourished food for young children. Prolonged insufficient nutrient intake may lead to chronic energy deficiency (CED) (Yuliastanti *et al*., 2023). Conversely, optimal nutritional and health status can be achieved when the body receives and efficiently utilizes sufficient dietary intake (Mousa *et al*., 2019). Meanwhile, Sutarmi *et al*. (2022) investigated

the efficacy of healthy massage on the growth and development of stunting infants. The study revealed a statistically significant enhancement in personal social development (p=0.03) compared to the control group. Additionally, anthropometric measurements significantly improved upper arm circumference (p=0.000) and body length (p=0.019). Consequently, the findings suggest that healthy massage constitutes an efficacious intervention for ameliorating the growth and development of stunted infants.

The research conducted by Maulida *et al*. (2024) on the effect of Tui Na Massage on the growth of stunted young children revealed a difference in the average body weight of 0.18 (180 grams) and body height of 1.15 cm before and after the administration of Tui Na Massage. The statistical test results yielded a p-value of 0.012 (p<0.05), indicating a significant effect of Tui Na Massage on increasing the weight of stunted young children. Furthermore, the study demonstrated an effect of Tu ina Massage on increasing height, with a p-value of 0.003 (p<0.05). These findings suggest that Tui Na Massage may be considered an alternative therapy for preventing and treating stunting in young children. Rangkuti (2022) conducted research on the effectiveness of tui na massage in increasing appetite in young children who experienced difficulty eating. The results demonstrated a p-value of 0.0000, suggesting that tui na massage was efficacious in enhancing appetite in young children in Medan City. The findings indicated that consistent application of tui na massage correlates positively with increased appetite in toddlers. It is recommended that mothers of young children implement this massage technique regularly.

Conclusion

The research concluded that there was a statistically significant difference between the treatment group and the non-treatment group regarding implementing a developed model of stunting management in young children. Furthermore, the study demonstrated a substantial impact of administering local weaning foods, baby massage therapy, and Tui Na massage therapy on stunted young children, as evidenced by increased body weight and height in the treatment group. Conversely, no significant difference was observed in the body weight and height of the stunted young children before and after the experiment in the non-treatment (control) group. The researchers extend their sincere appreciation to Bumi Persada University for supporting the implementation of this study and for providing funding assistance for the publication of this research.

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KEMAS 21 (2) (2025) 321-332

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Moringa Leaves-Added Food, Baby Massage, and Tui Na Massage to Reduce Stunting Rate on Young Children in Indonesia

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Article Info

Article History:
Submitted: April 2025
Accepted: September 2025
Published: October 2025

Keywords:
diet; malnutrition; massage; moringa; stunting

DOI
https://doi.org/10.15294/kemas.v21i2.24094

Abstract

Stunting remains a significant public health issue in Indonesia, particularly in Aceh Province, where the prevalence reached 33.18% in 2021—exceeding the WHO threshold. In North Aceh District, 14.3% of children under five were stunted, with Simpang Keramat District reporting one of the highest rates (35%). This study aimed to evaluate the effectiveness of a combined intervention—Moringa leaf-supplemented food within a balanced diet, baby massage, and Tui Na massage—in improving the nutritional status of stunted children aged 0–2 years. A quasi-experimental pre-post design was used, involving 50 stunted children divided equally into treatment and control groups. The intervention was conducted over 2.5 months. Paired t-test results showed significant increases in weight ($t24 = -6.656$, $p < .000$) and height ($t24 = -3.244$, $p < .003$) in the treatment group compared to the control group. These findings suggest that combining dietary fortification using locally available Moringa leaves with physical stimulation through massage therapy can effectively enhance growth outcomes. Given the multifactorial nature of stunting, this study recommends that nurses and health practitioners incorporate both nutrition-based interventions and sensory-stimulating therapies to address growth delays in young children, particularly in high-risk areas such as Aceh.

Introduction

Demographics are more susceptible to dietary deficiencies and diseases. Toddlers are particularly vulnerable to malnutrition in terms of both body weight and height (De and Chattopadhyay, 2019; Dipasquale *et al*., 2020). The consequences of inadequate nutritional intake are multifaceted and include growth impairment. This condition is characterized by suboptimal functioning of bodily organs (Awuchi *et al*., 2020; Kiani *et al*., 2022; Setiani *et al*., 2024). Furthermore, children may exhibit compromised immunity, increasing susceptibility to various ailments, such as respiratory tract infections, diarrhea, and fever. Consequently, a physical state prone to illness may result in less qualified human resources (HR) (Sampah & Hackam, 2020; Singh *et al*., 2022; Amoadu *et al*., 2024). Stunting, defined as a failure to thrive in young children due to chronic malnutrition, results in children being shorter than expected for their age (Scheffler *et al*., 2020; Ali, 2021; Schneider, 2025). Stunting manifests as a toddler's inability to thrive due to persistent malnutrition, causing the child to be shorter than anticipated for their age. Malnutrition occurs from infancy, encompassing the prenatal and early postnatal stages; however, its effects typically become apparent when the child reaches two years of age (Morales *et al*., 2023; Najib *et al*., 2023; Tjandrawinata *et al*., 2025).

Stunting is a condition observed in children aged 0–59 months when their height-

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pISSN 1858-1196
eISSN 2355-3596

for-age falls below minus two standard deviations (<-2SD) from the World Health Organization (WHO) median criterion. This condition results in impaired brain development and adversely affects cognitive capacity (Scheffler & Hermanussen, 2022; Priyantini *et al*., 2024; Amaha, 2025). Consequently, this diminishes the potential for higher educational attainment and reduces opportunities for enhanced income prospects. Moreover, children who survive stunting exhibit a propensity towards obesity and an increased likelihood of developing non-communicable diseases (NCDs), including hypertension, diabetes, and cancer (Rachmah *et al*., 2021; Kamal, 2022; Karlsson *et al*., 2022; Naga Rajeev *et al*., 2022; Nugroho *et al*., 2023).

The stunting prevalence in Indonesia exceeds the World Health Organization (WHO) threshold by 20%, with particularly concerning rates in Aceh Province. In 2022, 148.1 million (22.3%) children under 5 years of age exhibited insufficient height for their age (stunting), 45.0 million demonstrated insufficient weight for their height (wasting), and 37.0 million (5.6%) exhibited excessive weight for their height (overweight) (WHO, 2023; Setyawati *et al*., 2024). The Indonesian Nutrition Case Study 2021 revealed that Aceh Province has the highest rate of stunting in Indonesia at 33.18% (Sakti *et al*., 2023; Fitriahadi *et al*., 2024). According to the Indonesian Ministry of National Development Planning (Bappenas) and the United Nations International Children's Emergency Fund (UNICEF) in 2018, stunted growth is attributed to chronic malnutrition throughout a child's first 1,000 days of life. Multiple factors contribute to stunting among young children, including familial and environmental factors that influence their nutritional status. Insufficient nutrient intake and recurrent illnesses result in decreased nutritional status. Consequently, environmental factors, family conditions, and behaviors that facilitate infection affect toddler nutrition. The calorie and protein per capita per day for Indonesian children appear to be significantly lower than the Recommended Nutrient Intake (RNI) for typical children and those with stunting. Persistent problems may develop if this situation continues for an extended period (Kohl *et al*., 2022; Hawa *et al*., 2024; Nyarko *et al*., 2024).

The Indonesian Central Bureau of Statistics (2023) reported that 40,762 young children in North Aceh District, 14.3% of whom exhibited stunting. This positions North Aceh as the focal point for addressing the issue of stunting in Aceh Province, particularly in three sub-districts with the highest prevalence: Langkahan (35.29%), Simpang Keramat (35%), and Baktiya (34.48%). In 2022, the North Aceh District Government expanded the scope of its stunting intervention program for young children. The program now encompasses 40 hamlets distributed among 27 sub-districts, an increase from the previous coverage of 20 villages. Healthcare professionals and community health clinics in North Aceh have implemented stunting interventions. Consequently, a novel approach or combination of interventions is necessary to enhance the height and weight of young children with stunting.

Sutrisna *et al*. (2023) concluded that children who received the Moringa leaves intervention experienced higher weight gain than the control group. In the intervention group, 80% of toddlers exhibited weight gain of ≥2 kg, while only 15% demonstrated such gain in the control group. Statistical analysis indicated that the administration of Moringa leaves effectively increases the weight of young children in Mampree Village, Syamtalira Aron District, North Aceh Regency. Moringa is a plant rich in macro and micronutrients and is commonly cultivated in Aceh. The nutrients contained in Moringa leaves have been demonstrated to enhance the growth of young children. Consumption of Moringa leaf extract aids in ameliorating poor nutrition in young children, either through incorporation into weaning foods, direct consumption, or processing into complementary foods.

Based on research conducted by Yuniastuti *et al*. (2023) in The Effect of Providing Supplementary Food Based on Moringa Leaves and Sea Fish on Serum Zinc Levels of Stunting Young Children in Sedan, Rembang Regency in 2022, a study was conducted on 30 toddlers with stunting and severe stunting nutritional status in the Sedan Community Health Center working area of the Rembang Regency. For 63

days, the toddlers were administered additional food based on moringa leaves and selfishness. Following the intervention, the zinc levels in the blood and the mean height of the toddlers increased. Additionally, a significant correlation between zinc levels and toddler height was observed, suggesting that elevated zinc levels are closely associated with increased height. Research by Sutrisna *et al*. (2023a) investigated the efficacy of developing a culture-based dietary intervention by providing moringa leaf products through fortification in treating stunted toddlers. The quasi-experimental study utilized a sample size of 50 stunted toddlers divided into two groups: 25 in the treatment group and 25 in the control group. The findings demonstrated that the height of toddlers increased following the implementation of the dietary culture development by providing moringa leaf products via fortification. On average, toddlers' height increased by 2.9 cm. Based on the results of the paired sample t-test, a significance value of 0.003 <0.05 was obtained, indicating the effectiveness of developing a dietary culture by providing moringa leaf products through fortification in addressing stunting in toddlers within the Simpang Keramat Community Health Centre Working Area.

Research conducted by Sutarmi *et al*. (2022) regarding Baby Massage Intervention as an Effort to Prevent Stunting in Toddlers demonstrated that baby massage benefits include enhanced growth (weight and body length) and development (social and motor development). Baby massage may be utilized as a nursing intervention to mitigate the risk of toddler stunting. A randomized controlled trial conducted by Erçelik and Yılmaz (2023) examined the impact of infant massage on growth parameters and maternal-infant bonding. The study involved 60 healthy term infants and their mothers, who were randomly assigned to either a massage group or a control group. The massage group received online training and performed infant massage for 20 weeks. Results showed that infants in the massage group experienced significantly greater weight gain by the eighth week ($p = 0.006$) and increased height by the twentieth week ($p = 0.05$) compared to the control group. A systematic review and meta-analysis conducted by Mollà-Casanova *et al*. (2023) evaluated the effects of massage therapy—both alone and in combination with passive mobilizations—on weight gain and the duration of hospital stay in preterm infants. The study included randomized controlled trials that compared massage therapy interventions with standard care. The findings revealed that massage therapy combined with passive mobilizations significantly improved weight gain (standardized mean difference [95% CI]: 0.67 [0.31, 1.02]) and reduced the length of hospitalization (0.53 [0.10, 0.97]) in preterm infants. However, massage therapy alone did not demonstrate a statistically significant effect on weight gain (1.14 [−0.22, 2.49]).

Ningsih and Ramadhena (2023) investigated the effect of Tui Na massage on weight gain in young children in the Karawang Regency. The study population comprised 35 respondents who underwent Tui Na massage therapy in the Rengasdengklok and Karawang Districts. Bivariate analysis was conducted to examine the effect of Tui Na massage on increasing body weight in young children. The Wilcoxon signed-rank test yielded a p-value of 0.000, indicating a statistically significant impact of Tui Na massage on body weight in young children in the Karawang Regency. These findings suggest that Tui Na massage effectively promotes weight gain in young children. This study aimed to address the prevalence of stunting in Simpang Keramat District by modifying the interventions administered to children with stunting. The revised interventions focused on enhancing nutritional status to more effectively manage young children with stunting compared to existing methods. These interventions encompassed the provision of a nutritionally balanced diet supplemented with moringa leaves and applying massage therapy and Tui Na massage therapy to stimulate appetite.

Method

This study employed a quasi-experimental design. In this investigation, young children's weight and height were measured before the intervention. The treatments administered to modify the model included the provision of moringa leaf-supplemented food in a nutritionally balanced

diet, massage therapy, and Tui Na massage therapy for appetite stimulation. The young children's height and weight gain were measured following treatment completion. The study sample comprised stunted young children. Data and measurements were obtained from participants in Simpang Keramat Village and its Community Health Center Working Area. Independent stunting management interventions were implemented in the form of control, quality, and quantity instruments by modifying weaning food treatment, traditional massage therapy, and Tui Na massage therapy to enhance appetite. The incentive provided to participants was formula milk for their children. The researcher ensured the confidentiality of the participant's data by utilizing only the initials of the participant's name on the data collection sheet, and the researcher maintained the confidentiality of the data obtained in the study by restricting access to the subject data from other parties. The interview with each participant took approximately 20 minutes to get information on local weaning foods, diet, massage therapy conducted twice a week, and tui na massage for appetite for six consecutive days, and repeated one week apart. The weight and height of all participants were re-examined in both the intervention and control groups.

The research subjects were divided into two groups: the intervention group and the control group. The intervention group was given treatment in the form of a modified model through the provision of locally based complementary foods that are more nutritious, dietary regulation, infant massage therapy, and Tui Na massage. Before the treatment, an initial measurement of the child's weight and height was carried out, which was then re-measured after 2.5 months of therapy to see the changes. Meanwhile, the control group only received the usual care generally given, namely a balanced diet without additional interventions, as in the intervention group. Weight and height measurements in the control group were carried out at the beginning of the study and again after 2.5 months to compare the results with the intervention group. Purposive sampling was used to select 50 children aged 0-2 years from Simpang Keramat Village, North Aceh District, Aceh Province, Indonesia. The sample in this study comprised 25 children with stunting in the treatment group who received moringa leaf-supplemented food in their nutritionally balanced diet, infant massage therapy, and Tui Na massage. Conversely, 25 children with stunting in the control group received only a nutritionally balanced diet. The ratio of the intervention group to the control group was 1:1.

This study utilized a comprehensive approach to address stunting issues among children at the village community level. The process commenced with a systematic effort to understand and address the nutritional challenges experienced by children. The initial stages of the study involved meticulous preparation. The research team first obtained ethical approval from the relevant institution to ensure that all research procedures adhered to the moral standards of healthcare research. Upon receiving approval, we contacted local health authorities, particularly village midwives, to identify children experiencing stunting. The research team was formed multidisciplinarily and comprised primary researchers, research assistants, community health workers, and specialized massage therapists. Before the commencement of the study, all team members underwent comprehensive training. They were instructed on child anthropometric measurement techniques, massage therapy protocols, nutritional intervention preparation, and data collection and recording methodologies.

Nutritional intervention focused on utilizing moringa leaves, renowned for their nutritional density. Moringa leaves were procured from reputable local sources and subjected to thorough cleansing, desiccation, and pulverization into a fine powder. Nutritionists subsequently incorporated moringa leaf powder into complementary pediatric foods, ensuring nutritional consistency and dietary variation. An additional critical component of this study was massage therapy. Two distinct massage modalities were administered: generalized infant massage and Tui Na therapy. Infant massage was performed bi-weekly for 2.5 months, with each session lasting approximately 20-30 minutes. Tui Na therapy was implemented intensively for six consecutive days, followed by a one-week

hiatus, and then repeated. This therapy was specifically designed to stimulate children's appetite.

The measurements were conducted with a high degree of precision. Before and following the intervention, the research team measured the children's height and weight using standardized and calibrated equipment. Each measurement was performed by trained research assistants to ensure data accuracy. Participant adherence is a critical focus. Community support groups, field study teams, and community service student groups actively monitored the continuity of the intervention. They tracked therapy attendance, daily nutritional supplement consumption, and participation in massage therapy. Throughout the study, the research team actively engaged with children with stunting and their families. This interpersonal approach not only facilitated the collection of accurate data but also fostered community trust and engagement. Research integrity principles were held in high regard. The research team was committed to maintaining data credibility, dependability, confirmability, and transferability. Every step was meticulously documented, and each observation, intervention, and change was recorded. With this comprehensive approach, the research aimed to collect data and provide tangible interventions that could address stunting problems at the community level.

Result and Discussion

The research findings were derived from a sample of 50 respondents, comprising 25 individuals in the treatment group and 25 in the control group. Respondent characteristics were categorized into four variables: young children's gender, parents' occupation, and parents' education level. In the treatment group, female children constituted the majority, accounting for 13 (52%) participants, whereas the control group was predominantly male, with 15 (60%) participants. The primary occupation among parents in both groups was fishing, with nine individuals (36%) in the treatment group and 11 (44%) in the control group engaged in this profession. Regarding parental education, both groups exhibited a similar pattern, with high school graduates forming the most significant subset, with 17 (68%) in the treatment group and 19 (76%) in the control group. A detailed overview of the participants' characteristics is presented in Table 1.

Table 1. Respondents Characteristics (n=50)

Respondents' Characteristics	Treatment Group		Control Group	
	n	%	n	%
Young children Gender				
Man	12	48	15	60
Woman	13	52	10	40
Parents' Job				
Construction Workers	6	24	7	28
Civil Servants	5	20	4	16
Fisherman	9	36	11	44
Farmer	4	16	3	12
Housewives	1	4	0	0
Parental Education				
Elementary School	1	4	2	8
Junior High School	6	24	4	16
Senior High School	17	68	19	76
Bachelor	1	4	0	0

Table 2. Comparison of Toddlers' Weight and Height Gains Before and After Given Treatments Using Paired Sample t-test (n=50)

Characteristics	Mean	Std Deviation	t	P value*
Treatment Group				
Weight Before (kg)	11,160	1,3904	-6,656	0,000
Weight After (kg)	11,640	1,4347		
Height Before (cm)	87,192	7,3644	-3,244	0,003
Height After (cm)	90,028	7,4700		
Non-Treatment Group				
Weight Before (kg)	9,608	1,6894	0,989	0,332
Weight After (kg)	9,432	1,5771		
Height Before (cm)	79,012	13,5747	-1,159	0,258
Height After (cm)	81,052	8,5675		

* Paired t-test

Based on the results of research conducted by analysis, several examinations revealed that the number of participants utilized in this study was 50 stunted young children residing within the Simpang Keramat Community Health Center Working area. The sample was divided into a treatment group of 25 stunted young children and a control group of 25 stunted young children. The samples in this study were then examined for several characteristics, including sex, occupation, and parental education level. The majority of participants in the treatment group were young female children, comprising 13 stunted young children (52%). Conversely, 15 young male children (60%) were included in the control group (Table 1).

Regarding the occupational characteristics of the parents, the majority of parents in the treatment group, 9 individuals (36%), were employed as fishermen. Similarly, the majority in the control group, 11 individuals (44%), were also used as fishermen. Characteristics of the parents' educational level indicated that high school graduates constituted the majority in the treatment group (17 or 68%) and the control group (19 or 76%). Based on the results of the bivariate analysis, it was found that among the 50 samples, there was a significant difference before and after the experimental period between the stunted young children in the treatment and control groups. In the treatment group, young children's body weight before intervention had a mean value of 11.160 kg, and after intervention had a mean value of 11.640 kg. Thus, the difference in mean body weight before and after intervention was 0.48 kg. This indicates that there was weight gain in stunted young children in the treatment group. In the control group, the mean body weight of the stunted young children was 9.608 kg. Their body weight after 2.5 months was measured again and had a mean value of 9.432 kg. Thus, the difference in mean body weight before and after the experiment was -0.176 kg. This indicated a decrease in body weight of 0.176 kg in the stunted young children in the control group (Table 2).

Regarding body height, before applying the interventions to stunted young children, the mean height was 87.192 cm. Following treatment, the mean height of the stunted young children was 90.028 cm. Consequently, the difference in the mean height before and after treatment was 2.836 cm. This indicates that the treatments resulted in an increase in height among the stunted young children. In the control group, the mean initial height of previously stunted young children was 79.012 cm. After a 2.5-month observation period without any interventions administered to this group, the mean height of the young children was 81.052 cm. However, the difference in mean height before and after the 2.5-month

period was 2.04 cm, representing only a modest height gain (Table 2).

The nutritional status of young children improved following the interventions, as evidenced by post-treatment increases in weight and height among stunted young children. Specifically, stunted young children exhibited measurable gains in weight and height after the interventions compared to their pre-treatment measurements. On average, the weight of young children increased by 0.48 kg, while the mean height of young children post-intervention increased by 2.836 cm. The interventions administered to the stunted young children comprise nutritionally enhanced weaning foods (moringa leaves combined with local foods), infant massage, and Tui Na massage therapy, which are recognized to stimulate appetite in young children and demonstrate efficacy in enhancing eating behavior and physical development, thereby improving the nutritional status of stunted young children. In the non-intervention group of stunted young children, after 2.5 months, the toddlers' height increased marginally by 2.04 cm, while their weight decreased by 0.176 kg (Table 2).

The study results found that in the Treatment Group, the output of pair 1 produced a significance value of 0.000 (sig. < 0.05). As a result, it can be concluded that there is a statistically significant difference between the weight of young children before and after the treatment given in developing a model for stunting management through the provision of local complementary foods, infant massage, and Tui Na massage therapy to increase appetite. Furthermore, the output of pair 2 produced a significant value of 0.006 (sig. < 0.05), which indicates a statistically significant difference between the height of toddlers before and after the treatment given in developing a model for stunting management. This model combines local complementary foods, eating habits, infant massage, and Tui Na massage therapy for appetite stimulation (Table 2). In the Non-Treatment Group, the output of pair 3 produced a significant value of 0.332 (sig. > 0.05), indicating no statistically significant difference in toddler weight before and after 2.5 months. In addition, the output of Pair 4 produced an essential value of 0.258 (sig. > 0.05), indicating no statistically significant difference in toddler height before and after 2.5 months. The significance values (2-tailed) obtained were 0.000 and 0.003, both < 0.05. This indicates a significant influence on the experimental group that received treatment to develop a stunting management model, which includes local food-based complementary foods, eating habits, infant massage therapy, and Tui Na massage for appetite stimulation (Table 2).

Conversely, the control group, which did not receive any treatment, demonstrated no significant effect. Given these findings, it can be concluded that there is a substantial effect of providing complementary foods based on local food culture, diet, dietary habits, massage, and Tui Na massage for appetite stimulation in improving the nutritional status of stunted young children in the Simpang Keramat Community Health Center Working Area. Consequently, the Ha hypothesis was accepted, and the H0 hypothesis was rejected. The results of this research are corroborated by a study conducted by Fathnur *et al.* in 2019, which reported that moringa leaf pudding potentially increased the weight of undernourished young children by 100% in 17 intervention group respondents over three weeks, with a p-value of 0.039. Additionally, a study conducted by Hartina in 2022 found a p-value of 0.000 < 0.05, indicating a significant effect of moringa leaf extract on the nutritional status of young children, as measured by body weight and height (Table 2).

Lolan and Fauzia's research in 2023 demonstrated that local foods and parenting patterns influence the prevalence of stunting in young children aged 6-24 months in Bandung. The study employed a purposive sampling method, which revealed that fathers' education significantly affected stunting status, with a p-value of 0.034. Local food provision significantly influenced stunting in young children, with a p-value of 0.022 (p-value <0.05). Parenting patterns significantly affected stunting, with a p-value of 0.001 ($p < 0.05$). It can be concluded that the risk factors for stunting in young children are the father's education level, local food processing, and parenting patterns related to nutritious food. Fauziah and Krianto (2022) elucidated in their review the influence of

local food culture in preventing and addressing stunting in children under five years of age (6-59 months): Systematic Review. The findings from the review of seven selected journals indicate that local food culture improves the nutritional status of children under five years of age, particularly in the stunting prevention phase. However, in the prevention phase, local food culture utilizing processed food has not demonstrated efficacy in improving the nutritional status of young children already affected by stunting. Utilizing local food for young children suffering from stunting necessitates supplementation with other nutrients to yield a significant impact. Food and eating practices within communities possess cultural and social values; therefore, leveraging local food culture for young children's nutrition is accepted, readily accessible, and affordable for stunting prevention in specific regions.

Research by Diana *et al*. (2022) shows that the concept of eating and the perception of the Madurese community in Sampang Regency affect children's eating behavior and the incidence of stunting. Many parents consider short stature a hereditary factor, not a growth problem, as long as the child is active and wants to eat, which in their culture means eating rice. An unbalanced diet is considered harmless. Children with normal height tend to consume more varied foods than stunted children, who generally only eat rice with vegetable soup or fish broth without additional side dishes. This study emphasizes raising awareness about stunting and encouraging a more varied diet for children, not just relying on rice. Research about the development and optimization of cactus pear fruit jelly supplemented with Moringa oleifera leaf extract results indicated a significant difference in protein, fat, fiber, ash, carbohydrate, energy, iron, calcium, zinc, appearance, aroma, and taste among the formulated jellies ($p < 0.05$). The overall optimum nutritional and sensorial attributes of the jelly were found in a range of CFJ (70–73%), MOE (3–14%), and TS (20–26%). However, developing jelly with the formulation of CFJ (68 %), MOE (12%), and TS (20%) was predicted to give the highest nutritional value and sensory acceptability score (Akelom *et al*., 2022).

A study conducted in Benin by Founmilayo *et al*. (2023) involved 150 children aged 12–59 months with moderate acute malnutrition. The intervention group received porridge enriched with moringa leaf flour five times per week for six months. The results showed an average weight gain of 1.72 kg ($p < 0.005$) and a 10.42% reduction in the prevalence of acute malnutrition ($p < 0.005$) compared to the control group, which received only nutrition education. These findings are consistent with a study by Zongo (2018) in Burkina Faso, which reported that consuming moringa leaf powder for 12 weeks improved the nutritional status of preschool children, as indicated by increases in weight-for-height Z-scores (WHZ) and serum retinol concentrations. The nutrients contained in moringa leaves have been proven to promote child growth. Consumption of unhealthy snacks or 'junk' food poses a serious risk to a child's nutritional status. Moringa oleifera was selected for snack development because it is nutrient-rich (Zeeshan *et al*., 2024; Arshad *et al*. 2025). The survey showed that 87% of the caregivers gave children snacks daily. The snacks commonly given to children were savory (73%), fruity (53%), dairy (46%), and sugary (43%) types. The snacks containing 1% MOLP were almost as acceptable as the control regarding all sensory attributes evaluated, including overall acceptability. They had higher calcium, magnesium, potassium, phosphorus, zinc, manganese, iron, and crude protein concentrations but less fat than the control. The results indicate that snacks supplemented with MOLP can improve children's food and nutrition security status among vulnerable population groups (Olusanya *et al*., 2020).

Young children require adequate nutrition owing to their rapid growth and development, particularly during the first two years of life (Marshall *et al*., 2022). This accelerated growth and development period necessitates parental attention and the provision of nourished food for young children. Prolonged insufficient nutrient intake may lead to chronic energy deficiency (CED) (Yuliastanti *et al*., 2023). Conversely, optimal nutritional and health status can be achieved when the body receives and efficiently utilizes sufficient dietary intake (Mousa *et al*., 2019). Meanwhile, Sutarmi *et al*. (2022) investigated

the efficacy of healthy massage on the growth and development of stunting infants. The study revealed a statistically significant enhancement in personal social development (p=0.03) compared to the control group. Additionally, anthropometric measurements significantly improved upper arm circumference (p=0.000) and body length (p=0.019). Consequently, the findings suggest that healthy massage constitutes an efficacious intervention for ameliorating the growth and development of stunted infants.

The research conducted by Maulida *et al*. (2024) on the effect of Tui Na Massage on the growth of stunted young children revealed a difference in the average body weight of 0.18 (180 grams) and body height of 1.15 cm before and after the administration of Tui Na Massage. The statistical test results yielded a p-value of 0.012 (p<0.05), indicating a significant effect of Tui Na Massage on increasing the weight of stunted young children. Furthermore, the study demonstrated an effect of Tu ina Massage on increasing height, with a p-value of 0.003 (p<0.05). These findings suggest that Tui Na Massage may be considered an alternative therapy for preventing and treating stunting in young children. Rangkuti (2022) conducted research on the effectiveness of tui na massage in increasing appetite in young children who experienced difficulty eating. The results demonstrated a p-value of 0.0000, suggesting that tui na massage was efficacious in enhancing appetite in young children in Medan City. The findings indicated that consistent application of tui na massage correlates positively with increased appetite in toddlers. It is recommended that mothers of young children implement this massage technique regularly.

Conclusion

The research concluded that there was a statistically significant difference between the treatment group and the non-treatment group regarding implementing a developed model of stunting management in young children. Furthermore, the study demonstrated a substantial impact of administering local weaning foods, baby massage therapy, and Tui Na massage therapy on stunted young children, as evidenced by increased body weight and height in the treatment group. Conversely, no significant difference was observed in the body weight and height of the stunted young children before and after the experiment in the non-treatment (control) group. The researchers extend their sincere appreciation to Bumi Persada University for supporting the implementation of this study and for providing funding assistance for the publication of this research.

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KEMAS 21 (2) (2025) 348-359

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Nutritional Status of Children Aged 6-59 Months Based on Composite Index of Anthropometric Failure

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Article Info

Article History:
Submitted: May 2025
Accepted: September 2025
Published: October 2025

Keywords:
CIAF; energy intake; nutritional status

DOI
https://doi.org/10.15294/kemas.v21i2.25264

Abstract

Composite Index Anthropometric Failure (CIAF) is an alternative indicator for assessing nutritional status in children which can identify all children who are malnourished, whether they are stunting, wasting, underweight, wasting and underweight, stunting and underweight, or a combination of all three. The problem of failure to thrive in children aged 6-59 months based on CIAF in Bojongsari District, Depok City, in 2023 is 29,8%. This figure is higher than conventional measurements with single indicators of stunting, wasting, and underweight in Depok City based on the 2023 SKI, respectively, namely 14.3%, 5.8%, and 12.8%. The research aims to determine the determinants of the nutritional status of children aged 6-59 months based on CIAF in Bojongsari District, Depok City, West Java Province in 2023. This quantitative research with a cross-sectional study design used secondary data, and data analysis was conducted using the Chi-square test and multiple logistic regression. There were 317 children aged 6-59 months in this study. Bivariate analysis showed that variables related to children's nutritional status based on CIAF were energy intake, protein intake, fat intake, and carbohydrate intake. Multivariate analysis shows that energy intake is the risk factor in children's nutritional status based on CIAF in children aged 6-59 months in Bojongsari District, Depok City, West Java Province in 2023 after controlling for the variables protein intake and fat intake (p=0.006; OR = 3.493, 95% CI = 1.428 – 8.543).

Introduction

This study used a quantitative method with a cross-sectional research design to obtain an overview of the relationship between independent and dependent variables at the same time of observation. The study used secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023". The study population consisted of all children aged 0–59 months in the Bojongsari subdistrict, Depok City, West Java, who were registered as respondents in the primary study, totaling 359 children. The study sample was obtained using non-probability sampling with the total sampling method, and the test power was calculated using the hypothesis test formula for the difference between two proportions. The sample was determined based on inclusion and exclusion criteria. The inclusion criteria for the secondary study were children aged 6–59 months at the time of measurement. Meanwhile, the exclusion criteria for this study were if the Z-score for PB or TB/U was <-5 or >4, the Z-score for BB/U was <-5 or >8, and the Z-score for BB/TB or PB was <-4 or >8 (CDC, 2023). The number of secondary data samples was 317 children.

The independent variables used were energy intake, protein intake, fat intake, carbohydrate intake, animal

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pISSN 1858-1196
eISSN 2355-3596

protein consumption, dietary diversity, history of diarrhea, birth weight, complete basic immunization status, vitamin A supplementation status, food insecurity, use of contraceptives, number of family members, access to safe drinking water, and water management. The dependent variable studied was the nutritional status of children based on the CIAF. The secondary data in this study were obtained by reviewing the questionnaires used to collect data on child factors, family factors, and environmental factors. A 1x24-hour recall sheet was used to obtain data on infants' nutritional intake, an FFQ sheet was used to obtain data on animal protein consumption habits, and anthropometric measurements were used to obtain data on infants' nutritional status. Secondary data analysis was conducted in March–April 2024 at the Faculty of Public Health, University of Indonesia, Depok. The data analysis used in this study included univariate analysis to determine the frequency distribution of each variable studied, bivariate analysis using the Chi-Square test to determine the relationship between dependent and independent variables, and multivariate analysis using a logistic regression model to obtain the best independent variable model for predicting dependent variable outcomes.

Result And Discussion

Assessment of children's nutritional status based on the CIAF is more prevalent than the three conventional nutritional status

TABLE 1. Distribution of Respondents' Nutritional Status

Indicator	Number (n)	Presentation (%)
Weight-for-age (WAZ)		
Severely underweight	9	2,8
Underweight	32	10,1
Normal	247	77,9
Risk of overweight	29	9,1
Length/Height-for-age (HAZ)		
Severely stunted	22	6,9
Stunted	42	13,2
Normal	248	78,2
High	5	1,6
Weight-for-height (WHZ)		
Severely wasted	7	2,2
Wasted	24	7,6
Normal	232	73,2
Possible risk of being overweight	34	10,7
Overweight	14	4,4
Obese	6	1,9
CIAF		
Normal/no failure (A)	219	69,1
Wasting only (B)	14	4,4
Underweight & wasting (C)	14	4,4
Underweight, wasting, & stunting (D)	3	0,9
Underweight & stunting (E)	18	5,7
Stunting only (F)	43	13,6
Underweight only (Y)	6	1,9
Growth Failure (B+C+D+E+F+Y)	98	30,9

Source: Secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

indicators. Table 1 presents the distribution of nutritional status in children aged 6-59 months.

Table 1 shows that, based on conventional indices, children aged 6-59 months who experienced total underweight and severely underweight amounted to 12.9%, stunting and severely stunted amounted to 20.1%, and wasting and severely wasted amounted to 9.8%. The total number of children aged 6-59 months who experienced growth failure based on the CIAF was 30.9%. The largest category of growth failure was in category F, or only stunting, which

TABLE 2. Recapitulation of Univariate Analysis Results

Variable	Number (n)	Presentation (%)
Energy Intake		
Less (<100% AKG)	188	59,3
Adequate (≥100% AKG)	129	40,7
Protein Intake		
Less (<100% AKG)	37	11,7
Adequate (≥100% AKG)	280	88,3
Fat Intake		
Less (<100% AKG)	178	56,2
Adequate (≥100% AKG)	139	43,8
Carbohydrate Intake		
Less (<100% AKG)	253	79,8
Adequate (≥100% AKG)	64	20,2
Animal Protein Consumption Habits		
Non-Often (< mean)	155	48,9
Frequently (≥ mean)	162	51,1
Food Diversity		
Non-diverse (Skor < 5)	171	53,9
Diverse (Skor ≥ 5)	146	46,1
Diarrhea History		
Yes	66	20,8
No	251	79,2
Birth Weight		
Low Birth Weight (LBW) (< 3000 grams)	139	43,8
Normal (≥3000 grams)	178	56,2
Complete Basic Immunization Status		
Incomplete	123	38,8
Complete	194	61,2
Vitamin A Status		
Not Provided	45	14,2
Provided	272	85,8
Food Insecurity		
Vulnerable	196	61,8
Non-Vulnerable	121	38,2
Use of Family Planning Tools		
Not Using Family Planning	117	36,9
Using Family Planning	200	63,1
Number of Household Members		

Variable	Number (n)	Presentation (%)
Large (> 4 people)	118	37,2
Small (≤ 4 people)	199	62,8
Proper Drinking Water Facilities		
Not Proper	73	23,0
Proper	244	77,0
Drinking Water Management		
Unboiled (Water Not Boiled Before Consumption)	111	35
Boiled (Water Boiled Before Consumption)	206	65

Source: Secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

amounted to 13.6%. The results of univariate analysis in this study are presented in Table 2.

Most of the energy intake in children aged 6-59 months was in the less category (59.3%), protein intake was in the sufficient category (88.3%), fat intake was in the less category (56.2%), and carbohydrate intake was in the less category (79.8%). Animal protein consumption habits in children aged 6-59 months were mostly in the frequent category (51.1%), while food diversity was in the non-diverse category (53.9%). The results of the study of diarrhea history in children 6-59 months showed that most were in the category of having no history of diarrhea (79.2%). The birth weight of children aged 6-59 months was mostly in the normal category (56.2%). Most children aged 6-59 months in this study had complete basic immunization status in the complete category (61.2%) and vitamin A status in the provided category (85.8%). In the family factor, the highest percentage in the food insecurity variable was in the vulnerable category (61.8%), using family planning (63.1%), and the number of household members in the small category (62.8%). The environmental factor shows that the highest percentage in the variable of proper drinking water facilities is the proper category (77.0%) and drinking water management by boiling (65%).

The results of bivariate analysis showed that there were 4 variables associated (p-value <0.05) with nutritional status based on CIAF in children aged 6-59 months, namely energy intake, protein intake, fat intake, and carbohydrate intake. This shows that children aged 6-59 months who have less energy intake have a 4.568 times greater risk of experiencing growth failure based on CIAF than children who have sufficient intake. Based on the protein intake variable, it shows that children with insufficient protein intake have a 2.368 times higher risk of experiencing growth failure than children with adequate protein intake. The fat intake variable shows that children with insufficient fat intake have a 2.952 times higher risk of growth failure than children with sufficient fat intake. The carbohydrate intake variable shows that children with insufficient carbohydrate intake have a 3.316 times higher risk of experiencing growth failure than children with sufficient carbohydrate intake. A

TABLE 3. Recapitulation of bivariate analysis results

Variable	Nutritional Status Based on CIAF						OR (95% CI)	P-value
	Growth Failure		Normal		Total			
	n	%	n	%	N	%		
Energy Intake								
Less (<100% AKG)	80	42,6	108	57,4	188	100	4,568 (2,568-8,125)	<0,001*
Adequate (≥100% AKG)	18	14,0	111	86,0	129	100		
Protein Intake								
Less (<100% AKG)	18	48,6	19	51,4	37	100	2,368 (1,182-4,745)	0,022*
Adequate (≥100% AKG)	80	28,6	200	71,4	280	100		

Variable	Nutritional Status Based on CIAF						OR (95% CI)	P-value
	Growth Failure		Normal		Total			
	n	%	n	%	N	%		
Fat Intake								
Less (<100% AKG)	72	40,4	106	59,6	178	100	2,952 (1,754-4,970)	<0,001*
Adequate (≥100% AKG)	26	18,7	113	81,3	139	100		
Carbohydrate Intake								
Less (<100% AKG)	89	35,2	164	64,8	253	100	3,316 (1,566-7,024)	0,002*
Adequate (≥100% AKG)	9	14,1	55	85,9	64	100		
Animal Protein Consumption Habits								
Non-Often (< mean)	54	34,8	101	65,2	155	100	1,434 (0,889-2,314)	0,175
Frequently (≥ mean)	44	27,2	118	72,8	162	100		
Food Diversity								
Non-diverse (Skor < 5)	56	32,7	115	67,3	171	100	1,206 (0,746-1,949)	0,520
Diverse (Skor ≥ 5)	42	28,8	104	71,2	146	100		
Diarrhea History								
Yes	21	31,8	45	68,2	66	100	1,055 (0,588-1,890)	0,977
No	77	30,7	174	69,3	251	100		
Birth Weight								
LBW (< 3000 grams)	47	33,8	92	66,2	139	100	1,272 (0,788-2,053)	0,387
Normal (≥3000 grams)	51	28,7	127	71,3	178	100		
Complete Basic Immunization Status								
Incomplete	42	34,1	81	65,9	123	100	1,278 (0,787-2,076)	0,386
Complete	56	28,9	138	71,1	194	100		
Vitamin A Supplementation Status								
Not Provided	9	20,0	36	80,0	45	100	0,514 (0,237-1,114)	0,124
Provided	89	32,7	183	67,3	272	100		
Food Insecurity								
Vulnerable	66	33,7	130	66,3	196	100	1,412 (0,856-2,330)	0,220
Non-Vulnerable	32	26,4	89	73,6	121	100		
Use of Family Planning Tools								
Not Using Family Planning	36	31,0	80	69,0	116	100	1,009 (0,615-1,654)	1,000
Using Family Planning	62	30,8	139	69,2	201	100		
Number of Household Members								
Large (> 4 people)	38	32,2	80	67,8	118	100	1,100 (0,674-1,797)	0,798
Small (≤ 4 people)	60	30,2	139	69,8	199	100		
Proper Drinking Water Facilities								
Not Proper	23	31,5	50	68,5	73	100	1,037 (0,590-1,821)	1,000
Proper	75	30,7	169	69,3	244	100		
Drinking Water Management								
Unboiled (Water Not Boiled Before Consumption)	28	25,2	83	74,8	111	100	0,655 (0,391-1,098)	0,138
Boiled (Water Boiled Before Consumption)	70	34,0	136	66,0	206	100		

*P-value <0.05 (significant)

Source: SPSS analysis from secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

recapitulation of the bivariate analysis results is presented in Table 3.

In the next stage, candidate variables were selected by bivariate analysis of independent variables with dependent variables. The variables of energy intake, protein intake, fat intake, carbohydrate intake, animal protein consumption habits, vitamin A provision status, food insecurity, and drinking water management can continue to the modeling stage because they have a p-value <0.25. The variable of birth weight also continues to the modeling stage because it is considered important in the substance where birth weight is a factor that directly affects the nutritional status of children. The bivariate selection results

TABLE 4. Bivariate analysis results

Variable	P-value	Description
Energy Intake	<0,001*	Multivariate advanced
Protein Intake	0,016*	Multivariate advanced
Fat Intake	0,000*	Multivariate advanced
Carbohydrate Intake	0,001*	Multivariate advanced
Animal Protein Consumption Habits	0,139*	Multivariate advanced
Food Diversity	0,586	Not multivariate advanced
Diarrhea History	0,859	Not multivariate advanced
Birth Weight	0,325**	Multivariate advanced (substance)
Complete Basic Immunization	0,323	Not multivariate advanced
Vitamin A Supplementation Status	0,077*	Multivariate advanced
Food Insecurity	0,174*	Multivariate advanced
Use of Family Planning Tools	0,972	Not multivariate advanced
Number of Household Members	0,703	Not multivariate advanced
Proper Drinking Water Facilities	0,901	Not multivariate advanced
Drinking Water Management	0,104*	Multivariate advanced

*p-value <0.25; ** important in substance
Source: SPSS analysis from secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023"

TABLE 5. Multivariate First Model Results

Variable	P-value	aOR	95%CI
Energy Intake	0,006	3,493	1,428 – 8,543
Protein Intake	0,372	1,416	0,660 – 3,035
Fat Intake	0,638	1,183	0,587 – 2,384
Carbohydrate Intake	0,974	1,017	0,385 – 2,682
Animal Protein Consumption Habits	0,632	1,141	0,664 – 1,960
Birth Weight	0,712	0,908	0,543 – 1,517
Vitamin A Supplementation Status	0,115	0,507	0,218 – 1,180
Food Insecurity	0,486	1,218	0,700 – 2,119
Drinking Water Management	0,497	0,823	0,470 – 1,442

*p-value <0.05 (significant)
Source: SPSS analysis from secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

are presented in Table 4.

The first results of multivariate modeling are presented in Table 5. The multivariate modeling stages can be seen in Table 5. The table shows that modeling was then carried out, consisting of nine stages of multivariate analysis modeling. The modeling stages are carried out by looking from the largest p-value to the smallest and analyzing all variables simultaneously.

Furthermore, the interaction test was conducted on variables that were suspected to have substantial interaction, namely protein intake and energy intake. The results of the interaction test resulted in a p-value = 0.000 (p-value> 0.05), which means there is no interaction between protein intake and energy intake. Then, the interaction test was conducted again on fat intake and energy intake. The analysis results obtained p-value=0.269 (p-value>0.05), which means there is no interaction between fat intake and energy intake. Modeling has been completed; the valid model is a model without any interaction.

The final model was obtained after bivariate selection, and then modeling and interaction tests were conducted. The multivariate analysis showed that there was a variable that was significantly associated with children's nutritional status based on CIAF, namely energy intake (p-value=0.001). Energy intake was the dominant variable associated with children's nutritional status based on CIAF, with OR=3.663 (95% CI: 1.759 - 7.629). This means that children aged 6-59 months with insufficient energy intake have a 3.663 times higher risk of growth failure than children aged 6-59 months with sufficient energy intake after controlling for protein intake and fat intake. The final modeling results are presented in Table 6.

The results of this study are based on the results of conventional nutritional status indicators of children aged 6-59 months in Bojongsari Subdistrict, Depok City, which showed that 20.1% of children were stunted, 9.8% of children were wasted, and 12.9% were underweight. The prevalence of stunting, wasting, and underweight in an area is said to be a public health problem if, respectively, the prevalence is >20%, >5%, and >10% (WHO, 2022; De Onis *et al*., 2019). Based on the latest Indonesian Health Survey (IHS) data in 2023, the prevalence of stunting, wasting, and underweight in Depok City was 14.3%, 5.8%, and 12.8%, respectively (Kemenkes RI, 2023). When compared to the 2023 IHS results, the prevalence of underweight, stunting, and wasting in Bojongsari Sub-district in 2023 is still above the prevalence of Depok City.

The results of the study based on CIAF showed that the composite of children aged 6-59 months who experienced growth failure was 30.9%. In contrast, 69.1% of children had a normal nutritional status / no anthropometric failure. When compared with the results of the prevalence of nutritional status based on CIAF with research in other countries, these results are still lower than some studies such as in India (58.59%) (Dhok & Thakre, 2016), Bangladesh (48,3%) (Islam & Biswas, 2019), dan Ethiopia (46.7%) (Workie & Tesfaw, 2021). Here were 19.9% of children with one growth failure (categories B, F, Y), 10.1% of children with two growth failures (categories C and E), and 0.9% of children with three growth failures (category D). A study conducted in India stated that children who experienced more than one growth failure had a significantly increased risk of morbidity and mortality compared to the group of children who experienced only one growth failure (Nandy *et al*., 2005). Children with three growth failures based on CIAF have the highest risk of morbidity (Dewan *et al*.,

TABLE 6. Final Multivariate Modeling Results

Variable	B	P-Value	aOR	95% CI (Lower – Upper)
Energy Intake	1,298	0,001*	3,663	1,759 – 7,629
Protein Intake	0,325	0,380	1,384	0,646 – 2,508
Fat Intake	0,242	0,485	1,273	0,670 – 2,856

*P-value <0.05 (significant)

Source: SPSS analysis from secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

2016). The nutritional status of children can be known as a whole, especially when it can detect children who experience growth failure as a whole, so that it is expected to be the basis for making countermeasures or prevention programs for growth failure. Because if based only on one conventional nutritional status indicator, children who experience other nutritional status problems cannot be addressed, and children who experience more than one condition of growth failure cannot be identified.

The results of this study derived from child factors, there is a relationship between energy intake and less associated with growth failure, based on CIAF in children aged 6-59 months. In this study, children with less energy intake had a 4.568 times higher risk of experiencing growth failure than toddlers with sufficient energy intake. This is supported by research in India conducted on children under five years of age, also stating that toddlers with less energy intake have a 2.4 times higher risk of experiencing growth failure based on CIAF than toddlers with sufficient energy intake (Mohandas *et al*., 2023). After controlling for variables such as infectious diseases, fat intake, and carbohydrate intake, children with insufficient energy intake have a 5.9 times higher risk of stunting than toddlers with adequate energy intake (Werdani & Utari, 2020). Energy sources from food consist of several key nutrients, such as carbohydrates, protein, and fat, which are essential for growth, metabolism, and physical activity. Lack of energy intake can result in energy imbalance, which in turn can lead to nutritional problems such as Chronic Energy Deficiency (CED) and impact on a person's weight change (Bidira *et al*., 2021).

Other results from this study indicate that insufficient protein intake is a risk factor for growth failure based on CIAF (OR = 2.368). The study showed the tendency of respondents to consume sufficient protein intake, namely 88.3%. However, when viewed from the proportion of energy intake in children aged 6-59 months, most had insufficient energy intake (59.3%). Adequate energy intake to meet the needs of children will lead to a protein-sparing effect. This means that with sufficient energy intake, protein can be used for growth and tissue repair, rather than being used as an energy source (Balogun *et al.*, 2021). Most of the energy, fat, and carbohydrate intake of children aged 6-59 months in this study fell into the deficient category. When energy intake is deficient, along with fat and carbohydrate intake, protein is used as an energy source (Sahani *et al*., 2025). Adequate intake of overall energy, protein, fat, and carbohydrate can avoid growth failure in children.

In the fat intake variable, children with less fat intake have a 2.952 times higher risk of experiencing growth failure than toddlers with sufficient fat intake. In line with research in Karangmulyan village on 141 toddlers, which states that toddlers with insufficient fat intake have a 1.5 times higher risk of experiencing nutritional problems based on CIAF than toddlers with adequate fat intake (Anisadiyah & Sartika, 2022). Lack of fat intake, which then results in a decrease in energy in the body, can cause changes in body mass and tissue (Bidira *et al*., 2021). Other results from this study stated that children who have less carbohydrate intake have a 3.316 times higher risk of experiencing growth failure. This is in line with research in Bengkulu City, which suggests that toddlers with insufficient carbohydrate intake have an 8 times higher risk of experiencing growth failure compared to children with sufficient carbohydrate intake (Gassara & Chen, 2021).

Toddlers need adequate protein intake, especially from animal protein sources, to support optimal growth and development (Gropper *et al*., 2021). However, this study did not find a significant relationship between animal protein consumption habits and growth failure based on CIAF. These results are in line with experimental research in East Nusa Tenggara, which showed that there was no significant difference in changes in the nutritional status of toddlers before and after being given moringa nuggets to stunted children (Ariesthi *et al*., 2021). Another study mentioned that the habit of consuming milk during the day or at night was a protective factor against stunting based on CIAF in children aged 6-59 months in India (Vanderhout & Corsi, 2021). The non-significant results of the study could be due to the qualitative nature of the FFQ used in

this study, so researchers did not assess the size of the food consumed at each meal. Increased consumption of various foodstuffs indicates food diversity and can meet the nutritional needs of children completely (Rakotonirainy *et al*., 2018) . The insignificant relationship between food diversity and growth failure can be influenced because the diversity of food consumption cannot be assessed in terms of the portion and amount of intake. Nutritional status is not only influenced by food diversity but also by the frequency of feeding and how much food is received by toddlers (Wright *et al*., 2015).

The results of this study suggest that diarrhea is not associated with failure to thrive based on the CIAF. These results corroborate the evidence that, according to UNICEF's 2021 conceptual framework of the determinants of nutritional status in children, infectious diseases are not a direct cause of growth failure in children. The direct causes of growth failure in children are a good diet (child intake) and good child care practices (UNICEF, 2021). The results of this study from the child factor in the LBW variable stated that there was no significant relationship between LBW and growth failure based on CIAF. These results differ from research conducted in Gorontalo, which found that infants with low birth weight had a 7.3 times greater risk of stunting (Nurlaily *et al*., 2025). The data showed that 53.0% of information on the birth weight of children under five years old came from the mother's memory; the presence of bias in interviews or recording birth weight could cause statistical test results to show no significant relationship. Children who experience growth failure experience a decrease in important hormones that play a role in growth, such as insulin-like growth factor-1 (IGF-1) and thyroid hormones, resulting in a slowdown in linear growth (Berhe *et al*., 2019).

The results further stated that there was no significant relationship between complete basic immunization status and children's nutritional status based on CIAF. Research in Ethiopia also found no significant relationship between immunization status and child nutritional status based on the CIAF (Bidira *et al*., 2021). The adverse impact that can occur in children who do not get immunized is the increased risk of developing dangerous infectious diseases. Infectious diseases in children can prevent the optimal absorption of nutrients in the body (Jinarong *et al*., 2023). Vitamin A plays a role in various bodily functions, including immunity, growth, and development. Vitamin A insufficiency affects protein synthesis, which affects cell development (Gropper *et al*., 2021). However, the results of this study stated that there was no relationship between vitamin A provision status and nutritional status based on CIAF. The absence of a significant relationship between vitamin A supplementation status and nutritional status may be due to insufficient fat intake in children aged 6-59 months (56.2%).

The family factor in this study states that there is no relationship between food insecurity and nutritional status based on CIAF. When a household experiences food insecurity, they have limited access to sufficient and nutritious food (Sufyan *et al*., 2024). Forms of food insecurity include a lack of variety in diet and its link to poverty within the family, which can ultimately endanger children's growth and development (Gassara & Chen, 2021). The effect of food insecurity on children's nutritional status can also be influenced by other determinants such as maternal knowledge about child nutrition and health care practices, household food allocation and utilization practices, and access to health services (Motbainor *et al*., 2015). Another result of family factors in this study stated that there was no relationship between the use of family planning tools and nutritional status based on CIAF in children aged 6-59 months. This study is in line with research conducted in India using the Indian National Health and Family Survey data, which states that there is no significant relationship between the use of contraceptives and the incidence of stunting (Das *et al*., 2022). The variable family size in this study also stated that there was no relationship with the nutritional status of children aged 6-59 months based on CIAF. Families with a large number of members will compete for food, so that it does not meet the needs of toddlers. Toddlers who do not get enough intake and do not consume diverse foods can result in malnutrition (Workie & Tesfaw, 2021). The incidence of growth failure

is influenced by various direct factors, namely diet and good care practices for toddlers. The number of family members is not a direct factor in the incidence of failure to thrive in children under five (UNICEF, 2021).

There is no relationship between proper drinking water sources and nutritional status based on CIAF in children aged 6-59 months. The results of this study are in line with research conducted in Ethiopia on children under 59 months of age, which found no significant relationship between drinking water sources and stunting in toddlers (Toma *et al*., 2023). Research in Pakistan on children under 5 years of age states that drinking from unsuitable water sources has a risk of growth failure, based on a CIAF of 1.10 times compared to children who drink from suitable water sources (Balogun *et al*., 2021).This study can cause insignificant results because it only examined the type of water used for household drinking without paying attention to the physical, chemical, and microbiological quality of water. Based on the source, drinking water that is suitable for consumption must meet several requirements, namely be colorless, odorless, have a natural taste, and look physically clear.

In terms of biological parameters, drinking water that is suitable for consumption must be free from Escherichia Coli and Coliform bacteria. While drinking water is said to meet chemical requirements, namely if the water is free from the content of materials such as heavy metals, or mercury (Hg), lead (Pb), and aluminum (Au), iron, and chloride, and does not contain radioactive materials (WHO, 2022). Further results state that there is no relationship between drinking water management and nutritional status in children aged 6-59 months based on CIAF. It is important to ensure that drinking water is safe before consumption by treating it properly, such as boiling it. Boiling water kills pathogens that can contaminate water (Sahani *et al*., 2025). Insignificant results can be caused because the drinking water management variable only looks at whether the water is boiled or not, but does not look at the storage of the drinking water, whether in a closed container or not.

Multivariate results showed that children aged 6-59 months with insufficient energy intake had a 3.663 times higher risk of stunting compared to children aged 6-59 months with sufficient energy intake after controlling for the variables of protein intake and fat intake, in line with research in Tangerang, which states that children with insufficient energy intake have a 5.785 times higher risk of stunting than toddlers with sufficient energy intake, after controlling for infectious disease variables, fat intake, and carbohydrate intake (Werdani & Utari, 2020). Food intake directly affects the nutritional status of children. Inadequate nutrient intake, especially of total energy, protein, fat, carbohydrates, and micronutrients, is associated with physical growth deficits in pre-school children (Gropper *et al*., 2021).

Conclusion

The prevalence of growth failure based on CIAF among children under five years old in Bojongsari District, Depok City, West Java, in 2023 was 30.9%. The results of the prevalence of children who experience growth failure based on CIAF are greater than using conventional nutritional status indicators (BB/U, PB/U, BB/PB). The bivariate results stated that there were 4 variables associated with growth failure based on CIAF, namely, less energy intake, less protein intake, less fat intake, and less carbohydrate intake. Multivariate test results showed that the factor associated with nutritional status based on CIAF in children aged 6-59 months in Bojongsari District, Depok City, West Java was energy intake. Children aged 6-59 months with insufficient energy intake had a 3.663 times higher risk of growth failure compared to children aged 6-59 months who had sufficient energy intake after controlling for the variables of protein intake and fat intake. The results of this study are expected to provide helpful information and guidance for health workers in educating mothers of toddlers on how to record food intake in toddlers in the past week, especially those who experience growth failure. The results of these records can be collected with the KIA book so that health workers can examine them during Posyandu. The results of the toddler's food intake records can be the basis for educating health workers and mothers of toddlers about adequate food intake according to their needs, frequency, and portion size,

according to the child's age.

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KEMAS 21 (2) (2025) 348-359

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Nutritional Status of Children Aged 6-59 Months Based on Composite Index of Anthropometric Failure

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Article Info

Article History:
Submitted: May 2025
Accepted: September 2025
Published: October 2025

Keywords:
CIAF; energy intake; nutritional status

DOI
https://doi.org/10.15294/kemas.v21i2.25264

Abstract

Composite Index Anthropometric Failure (CIAF) is an alternative indicator for assessing nutritional status in children which can identify all children who are malnourished, whether they are stunting, wasting, underweight, wasting and underweight, stunting and underweight, or a combination of all three. The problem of failure to thrive in children aged 6-59 months based on CIAF in Bojongsari District, Depok City, in 2023 is 29,8%. This figure is higher than conventional measurements with single indicators of stunting, wasting, and underweight in Depok City based on the 2023 SKI, respectively, namely 14.3%, 5.8%, and 12.8%. The research aims to determine the determinants of the nutritional status of children aged 6-59 months based on CIAF in Bojongsari District, Depok City, West Java Province in 2023. This quantitative research with a cross-sectional study design used secondary data, and data analysis was conducted using the Chi-square test and multiple logistic regression. There were 317 children aged 6-59 months in this study. Bivariate analysis showed that variables related to children's nutritional status based on CIAF were energy intake, protein intake, fat intake, and carbohydrate intake. Multivariate analysis shows that energy intake is the risk factor in children's nutritional status based on CIAF in children aged 6-59 months in Bojongsari District, Depok City, West Java Province in 2023 after controlling for the variables protein intake and fat intake (p=0.006; OR = 3.493, 95% CI = 1.428 – 8.543).

Introduction

This study used a quantitative method with a cross-sectional research design to obtain an overview of the relationship between independent and dependent variables at the same time of observation. The study used secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023". The study population consisted of all children aged 0–59 months in the Bojongsari subdistrict, Depok City, West Java, who were registered as respondents in the primary study, totaling 359 children. The study sample was obtained using non-probability sampling with the total sampling method, and the test power was calculated using the hypothesis test formula for the difference between two proportions. The sample was determined based on inclusion and exclusion criteria. The inclusion criteria for the secondary study were children aged 6–59 months at the time of measurement. Meanwhile, the exclusion criteria for this study were if the Z-score for PB or TB/U was <-5 or >4, the Z-score for BB/U was <-5 or >8, and the Z-score for BB/TB or PB was <-4 or >8 (CDC, 2023). The number of secondary data samples was 317 children.

The independent variables used were energy intake, protein intake, fat intake, carbohydrate intake, animal

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pISSN 1858-1196
eISSN 2355-3596

protein consumption, dietary diversity, history of diarrhea, birth weight, complete basic immunization status, vitamin A supplementation status, food insecurity, use of contraceptives, number of family members, access to safe drinking water, and water management. The dependent variable studied was the nutritional status of children based on the CIAF. The secondary data in this study were obtained by reviewing the questionnaires used to collect data on child factors, family factors, and environmental factors. A 1x24-hour recall sheet was used to obtain data on infants' nutritional intake, an FFQ sheet was used to obtain data on animal protein consumption habits, and anthropometric measurements were used to obtain data on infants' nutritional status. Secondary data analysis was conducted in March–April 2024 at the Faculty of Public Health, University of Indonesia, Depok. The data analysis used in this study included univariate analysis to determine the frequency distribution of each variable studied, bivariate analysis using the Chi-Square test to determine the relationship between dependent and independent variables, and multivariate analysis using a logistic regression model to obtain the best independent variable model for predicting dependent variable outcomes.

Result And Discussion

Assessment of children's nutritional status based on the CIAF is more prevalent than the three conventional nutritional status

TABLE 1. Distribution of Respondents' Nutritional Status

Indicator	Number (n)	Presentation (%)
Weight-for-age (WAZ)		
Severely underweight	9	2,8
Underweight	32	10,1
Normal	247	77,9
Risk of overweight	29	9,1
Length/Height-for-age (HAZ)		
Severely stunted	22	6,9
Stunted	42	13,2
Normal	248	78,2
High	5	1,6
Weight-for-height (WHZ)		
Severely wasted	7	2,2
Wasted	24	7,6
Normal	232	73,2
Possible risk of being overweight	34	10,7
Overweight	14	4,4
Obese	6	1,9
CIAF		
Normal/no failure (A)	219	69,1
Wasting only (B)	14	4,4
Underweight & wasting (C)	14	4,4
Underweight, wasting, & stunting (D)	3	0,9
Underweight & stunting (E)	18	5,7
Stunting only (F)	43	13,6
Underweight only (Y)	6	1,9
Growth Failure (B+C+D+E+F+Y)	98	30,9

Source: Secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

indicators. Table 1 presents the distribution of nutritional status in children aged 6-59 months.

Table 1 shows that, based on conventional indices, children aged 6-59 months who experienced total underweight and severely underweight amounted to 12.9%, stunting and severely stunted amounted to 20.1%, and wasting and severely wasted amounted to 9.8%. The total number of children aged 6-59 months who experienced growth failure based on the CIAF was 30.9%. The largest category of growth failure was in category F, or only stunting, which

TABLE 2. Recapitulation of Univariate Analysis Results

Variable	Number (n)	Presentation (%)
Energy Intake		
Less (<100% AKG)	188	59,3
Adequate (≥100% AKG)	129	40,7
Protein Intake		
Less (<100% AKG)	37	11,7
Adequate (≥100% AKG)	280	88,3
Fat Intake		
Less (<100% AKG)	178	56,2
Adequate (≥100% AKG)	139	43,8
Carbohydrate Intake		
Less (<100% AKG)	253	79,8
Adequate (≥100% AKG)	64	20,2
Animal Protein Consumption Habits		
Non-Often (< mean)	155	48,9
Frequently (≥ mean)	162	51,1
Food Diversity		
Non-diverse (Skor < 5)	171	53,9
Diverse (Skor ≥ 5)	146	46,1
Diarrhea History		
Yes	66	20,8
No	251	79,2
Birth Weight		
Low Birth Weight (LBW) (< 3000 grams)	139	43,8
Normal (≥3000 grams)	178	56,2
Complete Basic Immunization Status		
Incomplete	123	38,8
Complete	194	61,2
Vitamin A Status		
Not Provided	45	14,2
Provided	272	85,8
Food Insecurity		
Vulnerable	196	61,8
Non-Vulnerable	121	38,2
Use of Family Planning Tools		
Not Using Family Planning	117	36,9
Using Family Planning	200	63,1
Number of Household Members		

Variable	Number (n)	Presentation (%)
Large (> 4 people)	118	37,2
Small (≤ 4 people)	199	62,8
Proper Drinking Water Facilities		
Not Proper	73	23,0
Proper	244	77,0
Drinking Water Management		
Unboiled (Water Not Boiled Before Consumption)	111	35
Boiled (Water Boiled Before Consumption)	206	65

Source: Secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

amounted to 13.6%. The results of univariate analysis in this study are presented in Table 2.

Most of the energy intake in children aged 6-59 months was in the less category (59.3%), protein intake was in the sufficient category (88.3%), fat intake was in the less category (56.2%), and carbohydrate intake was in the less category (79.8%). Animal protein consumption habits in children aged 6-59 months were mostly in the frequent category (51.1%), while food diversity was in the non-diverse category (53.9%). The results of the study of diarrhea history in children 6-59 months showed that most were in the category of having no history of diarrhea (79.2%). The birth weight of children aged 6-59 months was mostly in the normal category (56.2%). Most children aged 6-59 months in this study had complete basic immunization status in the complete category (61.2%) and vitamin A status in the provided category (85.8%). In the family factor, the highest percentage in the food insecurity variable was in the vulnerable category (61.8%), using family planning (63.1%), and the number of household members in the small category (62.8%). The environmental factor shows that the highest percentage in the variable of proper drinking water facilities is the proper category (77.0%) and drinking water management by boiling (65%).

The results of bivariate analysis showed that there were 4 variables associated (p-value <0.05) with nutritional status based on CIAF in children aged 6-59 months, namely energy intake, protein intake, fat intake, and carbohydrate intake. This shows that children aged 6-59 months who have less energy intake have a 4.568 times greater risk of experiencing growth failure based on CIAF than children who have sufficient intake. Based on the protein intake variable, it shows that children with insufficient protein intake have a 2.368 times higher risk of experiencing growth failure than children with adequate protein intake. The fat intake variable shows that children with insufficient fat intake have a 2.952 times higher risk of growth failure than children with sufficient fat intake. The carbohydrate intake variable shows that children with insufficient carbohydrate intake have a 3.316 times higher risk of experiencing growth failure than children with sufficient carbohydrate intake. A

TABLE 3. Recapitulation of bivariate analysis results

Variable	Nutritional Status Based on CIAF						OR (95% CI)	P-value
	Growth Failure		Normal		Total			
	n	%	n	%	N	%		
Energy Intake								
Less (<100% AKG)	80	42,6	108	57,4	188	100	4,568 (2,568-8,125)	<0,001*
Adequate (≥100% AKG)	18	14,0	111	86,0	129	100		
Protein Intake								
Less (<100% AKG)	18	48,6	19	51,4	37	100	2,368 (1,182-4,745)	0,022*
Adequate (≥100% AKG)	80	28,6	200	71,4	280	100		

Variable	Nutritional Status Based on CIAF						OR (95% CI)	P-value
	Growth Failure		Normal		Total			
	n	%	n	%	N	%		
Fat Intake								
Less (<100% AKG)	72	40,4	106	59,6	178	100	2,952 (1,754-4,970)	<0,001*
Adequate (≥100% AKG)	26	18,7	113	81,3	139	100		
Carbohydrate Intake								
Less (<100% AKG)	89	35,2	164	64,8	253	100	3,316 (1,566-7,024)	0,002*
Adequate (≥100% AKG)	9	14,1	55	85,9	64	100		
Animal Protein Consumption Habits								
Non-Often (< mean)	54	34,8	101	65,2	155	100	1,434 (0,889-2,314)	0,175
Frequently (≥ mean)	44	27,2	118	72,8	162	100		
Food Diversity								
Non-diverse (Skor < 5)	56	32,7	115	67,3	171	100	1,206 (0,746-1,949)	0,520
Diverse (Skor ≥ 5)	42	28,8	104	71,2	146	100		
Diarrhea History								
Yes	21	31,8	45	68,2	66	100	1,055 (0,588-1,890)	0,977
No	77	30,7	174	69,3	251	100		
Birth Weight								
LBW (< 3000 grams)	47	33,8	92	66,2	139	100	1,272 (0,788-2,053)	0,387
Normal (≥3000 grams)	51	28,7	127	71,3	178	100		
Complete Basic Immunization Status								
Incomplete	42	34,1	81	65,9	123	100	1,278 (0,787-2,076)	0,386
Complete	56	28,9	138	71,1	194	100		
Vitamin A Supplementation Status								
Not Provided	9	20,0	36	80,0	45	100	0,514 (0,237-1,114)	0,124
Provided	89	32,7	183	67,3	272	100		
Food Insecurity								
Vulnerable	66	33,7	130	66,3	196	100	1,412 (0,856-2,330)	0,220
Non-Vulnerable	32	26,4	89	73,6	121	100		
Use of Family Planning Tools								
Not Using Family Planning	36	31,0	80	69,0	116	100	1,009 (0,615-1,654)	1,000
Using Family Planning	62	30,8	139	69,2	201	100		
Number of Household Members								
Large (> 4 people)	38	32,2	80	67,8	118	100	1,100 (0,674-1,797)	0,798
Small (≤ 4 people)	60	30,2	139	69,8	199	100		
Proper Drinking Water Facilities								
Not Proper	23	31,5	50	68,5	73	100	1,037 (0,590-1,821)	1,000
Proper	75	30,7	169	69,3	244	100		
Drinking Water Management								
Unboiled (Water Not Boiled Before Consumption)	28	25,2	83	74,8	111	100	0,655 (0,391-1,098)	0,138
Boiled (Water Boiled Before Consumption)	70	34,0	136	66,0	206	100		

*P-value <0.05 (significant)

Source: SPSS analysis from secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

recapitulation of the bivariate analysis results is presented in Table 3.

In the next stage, candidate variables were selected by bivariate analysis of independent variables with dependent variables. The variables of energy intake, protein intake, fat intake, carbohydrate intake, animal protein consumption habits, vitamin A provision status, food insecurity, and drinking water management can continue to the modeling stage because they have a p-value <0.25. The variable of birth weight also continues to the modeling stage because it is considered important in the substance where birth weight is a factor that directly affects the nutritional status of children. The bivariate selection results

TABLE 4. Bivariate analysis results

Variable	P-value	Description
Energy Intake	<0,001*	Multivariate advanced
Protein Intake	0,016*	Multivariate advanced
Fat Intake	0,000*	Multivariate advanced
Carbohydrate Intake	0,001*	Multivariate advanced
Animal Protein Consumption Habits	0,139*	Multivariate advanced
Food Diversity	0,586	Not multivariate advanced
Diarrhea History	0,859	Not multivariate advanced
Birth Weight	0,325**	Multivariate advanced (substance)
Complete Basic Immunization	0,323	Not multivariate advanced
Vitamin A Supplementation Status	0,077*	Multivariate advanced
Food Insecurity	0,174*	Multivariate advanced
Use of Family Planning Tools	0,972	Not multivariate advanced
Number of Household Members	0,703	Not multivariate advanced
Proper Drinking Water Facilities	0,901	Not multivariate advanced
Drinking Water Management	0,104*	Multivariate advanced

*p-value <0.25; ** important in substance
Source: SPSS analysis from secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023"

TABLE 5. Multivariate First Model Results

Variable	P-value	aOR	95%CI
Energy Intake	0,006	3,493	1,428 – 8,543
Protein Intake	0,372	1,416	0,660 – 3,035
Fat Intake	0,638	1,183	0,587 – 2,384
Carbohydrate Intake	0,974	1,017	0,385 – 2,682
Animal Protein Consumption Habits	0,632	1,141	0,664 – 1,960
Birth Weight	0,712	0,908	0,543 – 1,517
Vitamin A Supplementation Status	0,115	0,507	0,218 – 1,180
Food Insecurity	0,486	1,218	0,700 – 2,119
Drinking Water Management	0,497	0,823	0,470 – 1,442

*p-value <0.05 (significant)
Source: SPSS analysis from secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

are presented in Table 4.

The first results of multivariate modeling are presented in Table 5. The multivariate modeling stages can be seen in Table 5. The table shows that modeling was then carried out, consisting of nine stages of multivariate analysis modeling. The modeling stages are carried out by looking from the largest p-value to the smallest and analyzing all variables simultaneously.

Furthermore, the interaction test was conducted on variables that were suspected to have substantial interaction, namely protein intake and energy intake. The results of the interaction test resulted in a p-value = 0.000 (p-value> 0.05), which means there is no interaction between protein intake and energy intake. Then, the interaction test was conducted again on fat intake and energy intake. The analysis results obtained p-value=0.269 (p-value>0.05), which means there is no interaction between fat intake and energy intake. Modeling has been completed; the valid model is a model without any interaction.

The final model was obtained after bivariate selection, and then modeling and interaction tests were conducted. The multivariate analysis showed that there was a variable that was significantly associated with children's nutritional status based on CIAF, namely energy intake (p-value=0.001). Energy intake was the dominant variable associated with children's nutritional status based on CIAF, with OR=3.663 (95% CI: 1.759 - 7.629). This means that children aged 6-59 months with insufficient energy intake have a 3.663 times higher risk of growth failure than children aged 6-59 months with sufficient energy intake after controlling for protein intake and fat intake. The final modeling results are presented in Table 6.

The results of this study are based on the results of conventional nutritional status indicators of children aged 6-59 months in Bojongsari Subdistrict, Depok City, which showed that 20.1% of children were stunted, 9.8% of children were wasted, and 12.9% were underweight. The prevalence of stunting, wasting, and underweight in an area is said to be a public health problem if, respectively, the prevalence is >20%, >5%, and >10% (WHO, 2022; De Onis *et al*., 2019). Based on the latest Indonesian Health Survey (IHS) data in 2023, the prevalence of stunting, wasting, and underweight in Depok City was 14.3%, 5.8%, and 12.8%, respectively (Kemenkes RI, 2023). When compared to the 2023 IHS results, the prevalence of underweight, stunting, and wasting in Bojongsari Sub-district in 2023 is still above the prevalence of Depok City.

The results of the study based on CIAF showed that the composite of children aged 6-59 months who experienced growth failure was 30.9%. In contrast, 69.1% of children had a normal nutritional status / no anthropometric failure. When compared with the results of the prevalence of nutritional status based on CIAF with research in other countries, these results are still lower than some studies such as in India (58.59%) (Dhok & Thakre, 2016), Bangladesh (48,3%) (Islam & Biswas, 2019), dan Ethiopia (46.7%) (Workie & Tesfaw, 2021). Here were 19.9% of children with one growth failure (categories B, F, Y), 10.1% of children with two growth failures (categories C and E), and 0.9% of children with three growth failures (category D). A study conducted in India stated that children who experienced more than one growth failure had a significantly increased risk of morbidity and mortality compared to the group of children who experienced only one growth failure (Nandy *et al*., 2005). Children with three growth failures based on CIAF have the highest risk of morbidity (Dewan *et al*.,

TABLE 6. Final Multivariate Modeling Results

Variable	B	P-Value	aOR	95% CI (Lower – Upper)
Energy Intake	1,298	0,001*	3,663	1,759 – 7,629
Protein Intake	0,325	0,380	1,384	0,646 – 2,508
Fat Intake	0,242	0,485	1,273	0,670 – 2,856

*P-value <0.05 (significant)

Source: SPSS analysis from secondary data from the results of primary research entitled "Analysis of Risk Factors for Stunting in Toddlers during the COVID-19 Pandemic Transition Period in Depok City in 2023".

2016). The nutritional status of children can be known as a whole, especially when it can detect children who experience growth failure as a whole, so that it is expected to be the basis for making countermeasures or prevention programs for growth failure. Because if based only on one conventional nutritional status indicator, children who experience other nutritional status problems cannot be addressed, and children who experience more than one condition of growth failure cannot be identified.

The results of this study derived from child factors, there is a relationship between energy intake and less associated with growth failure, based on CIAF in children aged 6-59 months. In this study, children with less energy intake had a 4.568 times higher risk of experiencing growth failure than toddlers with sufficient energy intake. This is supported by research in India conducted on children under five years of age, also stating that toddlers with less energy intake have a 2.4 times higher risk of experiencing growth failure based on CIAF than toddlers with sufficient energy intake (Mohandas *et al*., 2023). After controlling for variables such as infectious diseases, fat intake, and carbohydrate intake, children with insufficient energy intake have a 5.9 times higher risk of stunting than toddlers with adequate energy intake (Werdani & Utari, 2020). Energy sources from food consist of several key nutrients, such as carbohydrates, protein, and fat, which are essential for growth, metabolism, and physical activity. Lack of energy intake can result in energy imbalance, which in turn can lead to nutritional problems such as Chronic Energy Deficiency (CED) and impact on a person's weight change (Bidira *et al*., 2021).

Other results from this study indicate that insufficient protein intake is a risk factor for growth failure based on CIAF (OR = 2.368). The study showed the tendency of respondents to consume sufficient protein intake, namely 88.3%. However, when viewed from the proportion of energy intake in children aged 6-59 months, most had insufficient energy intake (59.3%). Adequate energy intake to meet the needs of children will lead to a protein-sparing effect. This means that with sufficient energy intake, protein can be used for growth and tissue repair, rather than being used as an energy source (Balogun *et al.*, 2021). Most of the energy, fat, and carbohydrate intake of children aged 6-59 months in this study fell into the deficient category. When energy intake is deficient, along with fat and carbohydrate intake, protein is used as an energy source (Sahani *et al*., 2025). Adequate intake of overall energy, protein, fat, and carbohydrate can avoid growth failure in children.

In the fat intake variable, children with less fat intake have a 2.952 times higher risk of experiencing growth failure than toddlers with sufficient fat intake. In line with research in Karangmulyan village on 141 toddlers, which states that toddlers with insufficient fat intake have a 1.5 times higher risk of experiencing nutritional problems based on CIAF than toddlers with adequate fat intake (Anisadiyah & Sartika, 2022). Lack of fat intake, which then results in a decrease in energy in the body, can cause changes in body mass and tissue (Bidira *et al*., 2021). Other results from this study stated that children who have less carbohydrate intake have a 3.316 times higher risk of experiencing growth failure. This is in line with research in Bengkulu City, which suggests that toddlers with insufficient carbohydrate intake have an 8 times higher risk of experiencing growth failure compared to children with sufficient carbohydrate intake (Gassara & Chen, 2021).

Toddlers need adequate protein intake, especially from animal protein sources, to support optimal growth and development (Gropper *et al*., 2021). However, this study did not find a significant relationship between animal protein consumption habits and growth failure based on CIAF. These results are in line with experimental research in East Nusa Tenggara, which showed that there was no significant difference in changes in the nutritional status of toddlers before and after being given moringa nuggets to stunted children (Ariesthi *et al*., 2021). Another study mentioned that the habit of consuming milk during the day or at night was a protective factor against stunting based on CIAF in children aged 6-59 months in India (Vanderhout & Corsi, 2021). The non-significant results of the study could be due to the qualitative nature of the FFQ used in

this study, so researchers did not assess the size of the food consumed at each meal. Increased consumption of various foodstuffs indicates food diversity and can meet the nutritional needs of children completely (Rakotonirainy *et al*., 2018) . The insignificant relationship between food diversity and growth failure can be influenced because the diversity of food consumption cannot be assessed in terms of the portion and amount of intake. Nutritional status is not only influenced by food diversity but also by the frequency of feeding and how much food is received by toddlers (Wright *et al*., 2015).

The results of this study suggest that diarrhea is not associated with failure to thrive based on the CIAF. These results corroborate the evidence that, according to UNICEF's 2021 conceptual framework of the determinants of nutritional status in children, infectious diseases are not a direct cause of growth failure in children. The direct causes of growth failure in children are a good diet (child intake) and good child care practices (UNICEF, 2021). The results of this study from the child factor in the LBW variable stated that there was no significant relationship between LBW and growth failure based on CIAF. These results differ from research conducted in Gorontalo, which found that infants with low birth weight had a 7.3 times greater risk of stunting (Nurlaily *et al*., 2025). The data showed that 53.0% of information on the birth weight of children under five years old came from the mother's memory; the presence of bias in interviews or recording birth weight could cause statistical test results to show no significant relationship. Children who experience growth failure experience a decrease in important hormones that play a role in growth, such as insulin-like growth factor-1 (IGF-1) and thyroid hormones, resulting in a slowdown in linear growth (Berhe *et al*., 2019).

The results further stated that there was no significant relationship between complete basic immunization status and children's nutritional status based on CIAF. Research in Ethiopia also found no significant relationship between immunization status and child nutritional status based on the CIAF (Bidira *et al*., 2021). The adverse impact that can occur in children who do not get immunized is the increased risk of developing dangerous infectious diseases. Infectious diseases in children can prevent the optimal absorption of nutrients in the body (Jinarong *et al*., 2023). Vitamin A plays a role in various bodily functions, including immunity, growth, and development. Vitamin A insufficiency affects protein synthesis, which affects cell development (Gropper *et al*., 2021). However, the results of this study stated that there was no relationship between vitamin A provision status and nutritional status based on CIAF. The absence of a significant relationship between vitamin A supplementation status and nutritional status may be due to insufficient fat intake in children aged 6-59 months (56.2%).

The family factor in this study states that there is no relationship between food insecurity and nutritional status based on CIAF. When a household experiences food insecurity, they have limited access to sufficient and nutritious food (Sufyan *et al*., 2024). Forms of food insecurity include a lack of variety in diet and its link to poverty within the family, which can ultimately endanger children's growth and development (Gassara & Chen, 2021). The effect of food insecurity on children's nutritional status can also be influenced by other determinants such as maternal knowledge about child nutrition and health care practices, household food allocation and utilization practices, and access to health services (Motbainor *et al*., 2015). Another result of family factors in this study stated that there was no relationship between the use of family planning tools and nutritional status based on CIAF in children aged 6-59 months. This study is in line with research conducted in India using the Indian National Health and Family Survey data, which states that there is no significant relationship between the use of contraceptives and the incidence of stunting (Das *et al*., 2022). The variable family size in this study also stated that there was no relationship with the nutritional status of children aged 6-59 months based on CIAF. Families with a large number of members will compete for food, so that it does not meet the needs of toddlers. Toddlers who do not get enough intake and do not consume diverse foods can result in malnutrition (Workie & Tesfaw, 2021). The incidence of growth failure

is influenced by various direct factors, namely diet and good care practices for toddlers. The number of family members is not a direct factor in the incidence of failure to thrive in children under five (UNICEF, 2021).

There is no relationship between proper drinking water sources and nutritional status based on CIAF in children aged 6-59 months. The results of this study are in line with research conducted in Ethiopia on children under 59 months of age, which found no significant relationship between drinking water sources and stunting in toddlers (Toma *et al*., 2023). Research in Pakistan on children under 5 years of age states that drinking from unsuitable water sources has a risk of growth failure, based on a CIAF of 1.10 times compared to children who drink from suitable water sources (Balogun *et al*., 2021).This study can cause insignificant results because it only examined the type of water used for household drinking without paying attention to the physical, chemical, and microbiological quality of water. Based on the source, drinking water that is suitable for consumption must meet several requirements, namely be colorless, odorless, have a natural taste, and look physically clear.

In terms of biological parameters, drinking water that is suitable for consumption must be free from Escherichia Coli and Coliform bacteria. While drinking water is said to meet chemical requirements, namely if the water is free from the content of materials such as heavy metals, or mercury (Hg), lead (Pb), and aluminum (Au), iron, and chloride, and does not contain radioactive materials (WHO, 2022). Further results state that there is no relationship between drinking water management and nutritional status in children aged 6-59 months based on CIAF. It is important to ensure that drinking water is safe before consumption by treating it properly, such as boiling it. Boiling water kills pathogens that can contaminate water (Sahani *et al*., 2025). Insignificant results can be caused because the drinking water management variable only looks at whether the water is boiled or not, but does not look at the storage of the drinking water, whether in a closed container or not.

Multivariate results showed that children aged 6-59 months with insufficient energy intake had a 3.663 times higher risk of stunting compared to children aged 6-59 months with sufficient energy intake after controlling for the variables of protein intake and fat intake, in line with research in Tangerang, which states that children with insufficient energy intake have a 5.785 times higher risk of stunting than toddlers with sufficient energy intake, after controlling for infectious disease variables, fat intake, and carbohydrate intake (Werdani & Utari, 2020). Food intake directly affects the nutritional status of children. Inadequate nutrient intake, especially of total energy, protein, fat, carbohydrates, and micronutrients, is associated with physical growth deficits in pre-school children (Gropper *et al*., 2021).

Conclusion

The prevalence of growth failure based on CIAF among children under five years old in Bojongsari District, Depok City, West Java, in 2023 was 30.9%. The results of the prevalence of children who experience growth failure based on CIAF are greater than using conventional nutritional status indicators (BB/U, PB/U, BB/PB). The bivariate results stated that there were 4 variables associated with growth failure based on CIAF, namely, less energy intake, less protein intake, less fat intake, and less carbohydrate intake. Multivariate test results showed that the factor associated with nutritional status based on CIAF in children aged 6-59 months in Bojongsari District, Depok City, West Java was energy intake. Children aged 6-59 months with insufficient energy intake had a 3.663 times higher risk of growth failure compared to children aged 6-59 months who had sufficient energy intake after controlling for the variables of protein intake and fat intake. The results of this study are expected to provide helpful information and guidance for health workers in educating mothers of toddlers on how to record food intake in toddlers in the past week, especially those who experience growth failure. The results of these records can be collected with the KIA book so that health workers can examine them during Posyandu. The results of the toddler's food intake records can be the basis for educating health workers and mothers of toddlers about adequate food intake according to their needs, frequency, and portion size,

according to the child's age.

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KEMAS 21 (2) (2025) 369-377

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Perinatal Mental Health Disorders in Indonesia: A Systematic Review of Quantitative Studies (2015–2024)

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Article Info

Article History:
Submitted: June 2025
Accepted: September 2025
Published: October 2025

Keywords:
perinatal mental health; depression, anxiety; risk factors; maternal health; Indonesia

DOI
https://doi.org/10.15294/kemas.v21i2.26267

Abstract

Perinatal mental health disorders, especially depression and anxiety, are prevalent among women in low- and middle-income countries (LMICs), including Indonesia. These conditions can affect both maternal well-being and child development. This systematic review aimed to identify and synthesize key risk factors associated with perinatal mental health disorders among women in Indonesia. A systematic search was conducted in PubMed, Scopus, and Google Scholar for quantitative studies published between 2015 and 2024. Inclusion criteria included studies involving pregnant or postpartum women in Indonesia, using quantitative designs, and reporting on risk factors for depression and/or anxiety. The review followed PRISMA 2020 guidelines. Data extraction and screening were conducted manually by reviewers. Out of 434 identified records, six studies met the inclusion criteria. Most employed cross-sectional designs focused on sociodemographic, psychosocial, obstetric, and psychological factors. Common risk factors included young maternal age, low education, unstable employment, lack of social support, and history of mental illness. Several studies also identified low mental health literacy and poor maternal-fetal attachment as contributing factors. The included studies were mostly cross-sectional, limiting causal inference. This review highlights the need for routine mental health screening, greater provider training, and community-based interventions in maternal health care. Future research should prioritize longitudinal designs and assess the effectiveness of policy implementation

Introduction

Perinatal mental health disorders, encompassing the period from pregnancy to one year postpartum, have become a major concern in global public health (Gelaye *et al*., 2016; Howard & Khalifeh, 2020). Disorders such as perinatal depression and anxiety can negatively impact not only maternal well-being but also child development, including emotional bonding, physical growth, mental health, and cognitive outcomes. These conditions are particularly prevalent in low- and middle-income countries (LMICs), where healthcare resources and access to mental health services remain limited. Without early detection and appropriate intervention, the consequences of these disorders can persist across generations and increase long-term public health burdens (Glover, 2014; WHO, 2022).

Globally, despite the high prevalence of perinatal mental disorders, detection and management rates remain alarmingly low, particularly in low- and middle-income countries (Howard & Khalifeh, 2020). Key barriers include limited capacity within primary healthcare services, insufficient training for health workers in mental health screening, pervasive social stigma surrounding mental illness, and low mental health literacy among pregnant women and their families (Shorey *et al*., 2018; WHO, 2022). To address these gaps, the World Health Organization (WHO, 2022)

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pISSN 1858-1196
eISSN 2355-3596

recommends the routine integration of mental health screening into antenatal and postnatal care services. Some countries have responded with national policies: NHS (National Health Service) England, through its Long Term Plan, has committed to expanding perinatal mental health services up to two years postpartum (NHS England, 2023), while Australia enforces its National Perinatal Mental Health Guidelines, advocating for at least one screening during pregnancy and another in the postpartum period (Gidget Foundation Australia, 2023).

Similar challenges are observed in Indonesia. National data indicate that the prevalence of Common Mental Disorders (CMD) among pregnant and postpartum women reaches 8.4%, yet most cases go undetected in primary care settings (Ariasih *et al*., 2024). A study in Jakarta Misrawati & Afiyanti, (2020) found that over 25% of pregnant women experienced antenatal depressive symptoms, although only a small proportion received counseling or further intervention. The absence of routine screening systems, limited training among health professionals, and persistent mental health stigma contribute to poor early detection rates.

Numerous studies in Indonesia have identified consistent risk factors associated with perinatal mental health disorders. These include young maternal age, low educational attainment, unstable employment, lack of social support, and a history of mental illness. (Setyorini *et al*., 2023) reported that pregnant women with lower education, unplanned pregnancies, and obstetric complications are at heightened risk of psychological distress. (Syam *et al*., 2020)) emphasized that lack of spousal support and household economic insecurity significantly contribute to prenatal depression. Furthermore, (Sari *et al*., 2023) highlighted that low mental health literacy and high levels of social stigma among pregnant women exacerbate delays in seeking professional help, echoing global patterns (Gelaye *et al*., 2016; Glover, 2014). In response to these concerns, the Indonesian Ministry of Health issued a national policy in 2023 mandating mental health screening for all pregnant and postpartum women. The screenings are to be conducted twice during pregnancy (at the first and fifth antenatal care visits) and once during the postpartum period (between 8–28 days after delivery) (Kemenkes RI, 2023). This policy is supported by the development of digital platforms such as SATUSEHAT Mobile and SIMKESWA to enhance technology-based early detection, as well as nationwide training programs for healthcare providers (Kemenkes RI, 2024).

Although research on perinatal mental health in Indonesia has been increasing, studies that systematically synthesize quantitative findings remain limited. A comprehensive review is necessary to identify key risk factors, inform the implementation of national screening policies, and strengthen maternal mental health services at the primary care level. Therefore, this study aims to systematically review quantitative studies published between 2015 and 2024 that examined risk factors associated with perinatal mental health disorders in Indonesia. The findings are expected to inform future research, policy formulation, and clinical practices that support the integration of mental health into maternal care.

Methods

This study is a systematic review aimed at identifying and synthesizing the risk factors associated with perinatal mental health disorders in Indonesia. The synthesis framework adopts the PICO approach (Population, Intervention, Comparison, Outcome), a widely used model in evidence-based health research. The reporting of this systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page *et al*., 2021). A systematic literature search was conducted in three databases: PubMed, Scopus, and Google Scholar. The search was carried out in January 2024, targeting articles published from January 1, 2015, to January 31, 2024, in English, and accessible in full text. The search strategy was developed using the PICO framework. The following keywords and Boolean operators were used: ("perinatal mental health" OR "Maternal mental health") AND ("depression" OR "anxiety") AND ("risk factors") AND ("Indonesia"). Duplicates were removed manually, and all screening was conducted independently by two reviewers.

Studies included in this synthesis met the following inclusion criteria:

Investigated perinatal mental health disorders (depression, anxiety, or both) among pregnant or postpartum women;

- Employed a quantitative research design (cross-sectional, cohort, or case-control);
- Focused on populations within Indonesia;
- Reported data on risk factors or determinants associated with perinatal mental health outcomes;
- Were published between 2015 and 2024, accessible in full-text, peer-reviewed, and sourced from reputable scientific journals indexed in international or national academic databases.

The exclusion criteria were as follows:

- Qualitative studies or other types of secondary literature reviews;
- Studies that did not focus on pregnant or postpartum women;
- Articles that were not available in full-text.

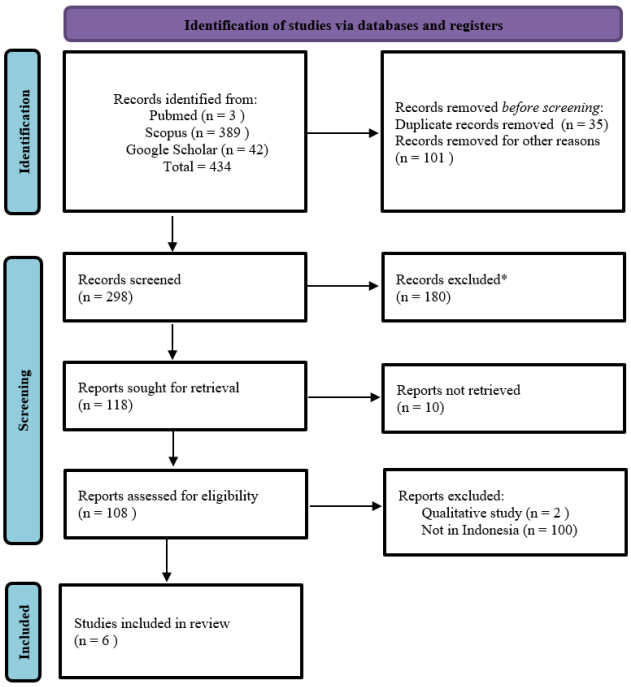
The study selection process followed the PRISMA 2020 flowchart, beginning with the initial identification of 434 articles retrieved from all databases. After removing duplicates and screening titles and abstracts, potentially relevant articles underwent full-text eligibility assessment. Studies that did not meet the inclusion criteria or were duplicate entries were excluded. A total of 6 studies met all inclusion criteria and were included in the final data synthesis.

Data from the six included studies were extracted independently by two reviewers using a standardized data extraction form. Discrepancies were resolved through discussion and consensus. The extracted items included: year of publication, study design, sample size, study location, population characteristics, investigated risk factors, and main findings related to perinatal depression or anxiety. The extracted data were then synthesized using a descriptive thematic approach and organized in both tabular and narrative forms. The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies, which is appropriate for the designs of the included articles. Each study was evaluated independently by two reviewers based on eight criteria, including sample selection, measurement validity, and confounding factors. All studies met at least six of the eight criteria, indicating moderate to high methodological quality. The most common limitations identified were unclear handling of confounding variables and limited information on response rates. Disagreements between reviewers were resolved by discussion.

Result and Discussion

A total of 434 records were identified through systematic searches in PubMed (n = 3), Scopus (n = 389), and Google Scholar (n = 42). After removing 35 duplicate records and 101 records excluded for other reasons (such as irrelevant titles or inaccessible sources), 298 titles and abstracts were screened. Following screening, 118 full-text articles were retrieved for eligibility assessment. Of these, 10 articles were not accessible, and 102 were excluded, with primary reasons including non-Indonesian context (n = 100) and qualitative design (n = 2). In total, 6 studies fulfilled the inclusion criteria and were included in this review. All included studies employed quantitative designs, mostly cross-sectional, and examined risk factors for perinatal depression and/or anxiety. No automation tools were used in the selection process. All screening and eligibility steps were conducted independently by two reviewers through manual assessment.

Following the study selection process illustrated in the PRISMA 2020 flow diagram (Figure 1), a total of six studies were included in the final synthesis. These studies, published between 2015 and 2025, were retrieved from reputable international peer-reviewed journals and predominantly applied quantitative approaches, particularly cross-sectional study designs. To support thematic analysis and comparison, key information was extracted and compiled into a structured table. The table below presents a summary of each included study, covering the title, research design, characteristics of the study population, focus of investigation, and the main outcomes related to



**No automation tools were used; all screening was conducted manually by the reviewers.

Figure 1. PRISMA 2020 Flow Diagram of Study Selection Process

Tables 1. Summary of Included Studies: Study Design, Population, Focus of Investigation, and Key Outcomes

NO	TITLE	STUDY DESAIN	POPULATION	FOCUS OF INVESTIGATION	OUTCOME
1.	Common Mental Disorders and Associated Factors During Pregnancy and the Postpartum Period in Indonesia: An Analysis of Data From the 2018 Basic Health Research (Ariasih *et al*., 2024)	Cross-sectional Survey	Pregnant and postpartum women aged 15–49 years who are or have been married based on RISKESDAS, 2018.	Exposure to risk factors (sociodemographic, health, and obstetric) that may increase the likelihood of experiencing CMDs (Common Mental Disorders)	Significant factors associated with CMDs include sociodemographic (age, education, employment status), health (hypertension history, general health, smoking status, MUAC), and obstetric (obstetric history, pregnancy trimester, abortion history, pregnancy complications). All three domains were significant in postpartum women.
2.	Identifying risk factors of prenatal depression among mothers in Indonesia (Syam *et al*., 2020)	Cross-sectional Study	321 pregnant women with gestational age ≥12 weeks in Makassar, South Sulawesi, Indonesia	Exposure to risk factors (sociodemographic, psychosocial, obstetric, lifestyle, and health) potentially increases prenatal depression	Prenatal anxiety and depression symptoms were significantly associated with husband's education, family income, birth planning, fear of childbirth, planned/ previous C-section, and partner support.

3.	Exploring perinatal mental health in Indonesia: A mixed-method study in Mataram, West Nusa Tenggara (Harahap *et al*., 2024)	Cross-sectional study and ethnographic approach	33 postpartum women within the first month at Babakan Health Center	Exposure to demographic, social & familial, mental health history, obstetric, and environmental & economic risk factors	The history of adolescent mental health disorders showed a significant association with increased risk of PMH issues.
4.	Maternal age as a main factor influencing prenatal distress in Indonesian Primigravida (Ayu *et al*., 2019)	Cross-sectional	A total of 214 primigravida mothers at community health centers in Banten Province, Indonesia, participated in the study	The research examined the influence of maternal age and other factors—such as education level, income, gestational age, social support, history of traumatic experiences, satisfaction with paternal support, and pregnancy planning—on prenatal distress.	The study found that maternal age was the most influential factor affecting stress during pregnancy.
5.	Maternal Factors Influencing Postpartum Depression in Indonesia (Sari *et al*., 2023)	Cross-sectional	251 postpartum women (2–8 weeks) in Bandar Lampung, February–May 2023	Risk factors for postpartum depression (abortion history, previous depression, employment, education, family support)	Abortion history, age, parity, education, prior depression, employment status, and family support were associated with postpartum depression.
6.	Antenatal depression and its associated factors among pregnant women in Jakarta, Indonesia (Misrawati & Afiyanti, 2020)	Cross-sectional study	196 pregnant women aged 20–40 years at Menteng, Senen, and Ciracas Health Centers	196 pregnant women aged 20–40 years at Menteng, Senen, and Ciracas Health Centers	Age, education, employment, parity, gestational age, pregnancy planning, and family type were not significantly correlated. The history of depression was significantly correlated with antenatal depression.

perinatal mental health disorders.

This systematic review synthesized findings from six quantitative studies conducted in Indonesia between 2015 and 2024. The results demonstrate that perinatal mental health disorders, particularly depression and anxiety, are consistently associated with sociodemographic (e.g., young maternal age, low education), psychosocial (e.g., lack of partner support), obstetric (e.g., history of complications), and psychological factors (e.g., previous depression). These findings are consistent with global patterns reported in the systematic review by Fisher *et al*. (2012), which highlighted a significantly higher prevalence of perinatal mental disorders in low- and middle-income countries, including Indonesia. Consistently, factors such as young maternal age, low educational attainment, unstable employment, and lack of social support emerged as key predictors of perinatal mental health disorders(Ariasih *et al*., 2024; Ayu *et al*., 2019; Misrawati & Afiyanti, 2020)

Maternal age, particularly adolescent pregnancy, indicates a greater vulnerability to stress and depression. A study in Indonesia

found that younger mothers were more likely to experience prenatal distress than older mothers (Ayu *et al*., 2019). This is reinforced by the findings of (Jose Tilman *et al*., 2024), who associated adolescent pregnancy with more severe postpartum depression and prolonged stress affecting child well-being. Similarly, Mollborn & Morningstar (2009), emphasized that adolescent pregnancy consistently increases the risk of poor mental health outcomes due to social pressure, stigma, and limited access to support services. Expanding on these findings, a recent literature review by Lesinskienė *et al*. (2025) underscores that adolescent pregnancy poses substantial mental health risks, particularly in low- and middle-income settings. Pregnant adolescents experience disproportionately high rates of depression, suicidal ideation, low self-esteem, substance use, and anxiety. The review highlights the urgency for comprehensive, long-term solutions and multidisciplinary approaches that can improve both the mental and physical health support available to this vulnerable group. These findings collectively point to the necessity of targeted interventions that are developmentally appropriate, culturally sensitive, and embedded within the broader reproductive and maternal healthcare systems.

Low educational attainment also emerged as a consistent risk factor for perinatal mental disorders. Setyorini *et al*. (2023) found that pregnant women with lower levels of education had a limited understanding of mental health information, resulting in delays in help-seeking. Gelaye *et al*. (2016) similarly, we found that low education exacerbated the risk of prenatal depression in LMICs, largely due to limited health literacy. In China. Zhang *et al*. (2025) identified health literacy as a key mediator between education level and prenatal depression—women with higher education were less likely to experience depression. Educational disadvantage is also linked to limited access to care, economic vulnerability, and greater dependency on partners.

Beyond age and education, social support plays a critical protective role in mitigating perinatal mental health disorders. In Indonesia, Syam *et al*. (2020) demonstrated that lack of partner support was significantly associated with prenatal depression. This finding aligns with a longitudinal study by Leigh & Milgrom (2008), which reported that emotional support from partners and family effectively reduced the risk of developing postpartum depression. Parallel findings in Vietnam (Nguyen *et al*., 2021) and Pakistan (Waqas *et al*., 2020) further emphasize the importance of social support in reducing the risk of depression among pregnant women in low-resource settings. More recently, Umuziga *et al*. (2023) found that insufficient social support from partners and family significantly increased postnatal depressive symptoms among mothers in Rwanda. Likewise, a prospective cohort study in Australia by Bedaso *et al*. (2021)revealed that pregnant women with lower levels of emotional and informational support had significantly higher odds of experiencing antenatal depressive symptoms. Collectively, these studies underscore the essential role of social support—whether emotional, instrumental, or informational—as a protective factor against perinatal mental health problems. Integrating psychosocial screening into routine antenatal care and strengthening family- and community-based support systems are crucial strategies to improve maternal mental health outcomes, particularly in low- and middle-income countries.

In addition, Harahap *et al*. (2024), through an ethnographic approach, highlighted adolescent mental health history as a significant risk factor for postpartum mental health disorders. This is consistent with findings from Rees *et al*. (2016) in Timor-Leste, which revealed that exposure to intimate partner violence (IPV) and past trauma significantly increased the risk of depression. This shows that mental health vulnerabilities can persist over time, and adolescence is a critical period for identifying early mental health risks. If left untreated, these problems can reappear or worsen during stressful life events—such as childbirth and early parenting.

Complementing these perspectives, Maulina *et al*., (2025) contributed additional insight by examining how psychological factors affect not only emotional well-being but also behavioral outcomes. In a cross-sectional study involving 224 pregnant women in Indonesia,

they found that maternal-fetal attachment and maternal prenatal depression were the strongest predictors of adopting a health-promoting lifestyle. The study revealed that stronger maternal-fetal attachment was associated with better nutrition, physical activity, and stress management, whereas prenatal depression was negatively correlated with those behaviors. This finding extends the discussion beyond mental health outcomes and suggests that psychological well-being directly influences the mother's capacity to engage in protective health behaviors during pregnancy.

The strength of this synthesis lies in its broad geographic representation across Indonesia, the use of nationally representative datasets such as RISKESDAS (Ariasih *et al*., 2024), and the integration of both quantitative and qualitative approaches. However, most of the studies employed a cross-sectional design, collecting data at a single point in time. Consequently, they are limited in establishing causal relationships. Although associations were observed between risk factors (e.g., young age, low education) and mental health disorders, these studies do not provide definitive evidence of causality. Longitudinal research or randomized controlled trials (RCTs) are needed to draw stronger causal inferences. While the review offers important insights, it is not without limitations. All included studies applied cross-sectional designs, which limit causal inference. Moreover, no formal meta-analysis was performed due to methodological heterogeneity in measurement tools and population characteristics.

These findings underscore the urgency of integrating routine mental health screening into Indonesia's maternal and child health services. In line with WHO recommendations (WHO, 2022), the Indonesian Ministry of Health has issued a national policy mandating annual mental health screening for the general population, and specifically three screenings for pregnant and postpartum women: twice during pregnancy (at the first and fifth antenatal visits) and once postpartum (between 8–28 days after delivery). Implementation of this policy has been supported by the development of digital platforms such as SATUSEHAT Mobile and SIMKESWA, which facilitate early detection of mental health issues in primary care. The Ministry has also initiated mental health screening training programs for healthcare providers across all provinces, demonstrating a strong government commitment to strengthening perinatal mental health services nationwide.

The practical implications of these findings point to the need for expanding primary healthcare provider training in early detection, initial management, and referral for perinatal mental health disorders. Integration with national programs such as "Gerakan Masyarakat Hidup Sehat (GERMAS)" offers opportunities to broaden community-based mental health promotion more systematically. Looking ahead, more longitudinal research and RCTs are needed to evaluate the effectiveness of various intervention models—both community-based and technology-driven—in preventing and addressing perinatal mental health disorders. Participatory qualitative studies are also crucial to better understand the lived emotional experiences of pregnant and postpartum women within Indonesia's cultural context.

Conclusion

This systematic review identified consistent risk factors contributing to perinatal mental health disorders in Indonesia, including young maternal age, low educational attainment, inadequate social support, and a history of mental illness. These findings underscore the urgent need to integrate routine mental health screening into maternal care, strengthen health worker capacity, and promote culturally sensitive interventions. Future studies employing longitudinal or interventional designs are essential to establish causal relationships and inform effective, scalable mental health strategies for Indonesian women during the perinatal period.

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KEMAS 21 (2) (2025) 369-377

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Perinatal Mental Health Disorders in Indonesia: A Systematic Review of Quantitative Studies (2015–2024)

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Article Info

Article History:
Submitted: June 2025
Accepted: September 2025
Published: October 2025

Keywords:
perinatal mental health; depression, anxiety; risk factors; maternal health; Indonesia

DOI
https://doi.org/10.15294/kemas.v21i2.26267

Abstract

Perinatal mental health disorders, especially depression and anxiety, are prevalent among women in low- and middle-income countries (LMICs), including Indonesia. These conditions can affect both maternal well-being and child development. This systematic review aimed to identify and synthesize key risk factors associated with perinatal mental health disorders among women in Indonesia. A systematic search was conducted in PubMed, Scopus, and Google Scholar for quantitative studies published between 2015 and 2024. Inclusion criteria included studies involving pregnant or postpartum women in Indonesia, using quantitative designs, and reporting on risk factors for depression and/or anxiety. The review followed PRISMA 2020 guidelines. Data extraction and screening were conducted manually by reviewers. Out of 434 identified records, six studies met the inclusion criteria. Most employed cross-sectional designs focused on sociodemographic, psychosocial, obstetric, and psychological factors. Common risk factors included young maternal age, low education, unstable employment, lack of social support, and history of mental illness. Several studies also identified low mental health literacy and poor maternal-fetal attachment as contributing factors. The included studies were mostly cross-sectional, limiting causal inference. This review highlights the need for routine mental health screening, greater provider training, and community-based interventions in maternal health care. Future research should prioritize longitudinal designs and assess the effectiveness of policy implementation

Introduction

Perinatal mental health disorders, encompassing the period from pregnancy to one year postpartum, have become a major concern in global public health (Gelaye *et al*., 2016; Howard & Khalifeh, 2020). Disorders such as perinatal depression and anxiety can negatively impact not only maternal well-being but also child development, including emotional bonding, physical growth, mental health, and cognitive outcomes. These conditions are particularly prevalent in low- and middle-income countries (LMICs), where healthcare resources and access to mental health services remain limited. Without early detection and appropriate intervention, the consequences of these disorders can persist across generations and increase long-term public health burdens (Glover, 2014; WHO, 2022).

Globally, despite the high prevalence of perinatal mental disorders, detection and management rates remain alarmingly low, particularly in low- and middle-income countries (Howard & Khalifeh, 2020). Key barriers include limited capacity within primary healthcare services, insufficient training for health workers in mental health screening, pervasive social stigma surrounding mental illness, and low mental health literacy among pregnant women and their families (Shorey *et al*., 2018; WHO, 2022). To address these gaps, the World Health Organization (WHO, 2022)

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pISSN 1858-1196
eISSN 2355-3596

recommends the routine integration of mental health screening into antenatal and postnatal care services. Some countries have responded with national policies: NHS (National Health Service) England, through its Long Term Plan, has committed to expanding perinatal mental health services up to two years postpartum (NHS England, 2023), while Australia enforces its National Perinatal Mental Health Guidelines, advocating for at least one screening during pregnancy and another in the postpartum period (Gidget Foundation Australia, 2023).

Similar challenges are observed in Indonesia. National data indicate that the prevalence of Common Mental Disorders (CMD) among pregnant and postpartum women reaches 8.4%, yet most cases go undetected in primary care settings (Ariasih *et al*., 2024). A study in Jakarta Misrawati & Afiyanti, (2020) found that over 25% of pregnant women experienced antenatal depressive symptoms, although only a small proportion received counseling or further intervention. The absence of routine screening systems, limited training among health professionals, and persistent mental health stigma contribute to poor early detection rates.

Numerous studies in Indonesia have identified consistent risk factors associated with perinatal mental health disorders. These include young maternal age, low educational attainment, unstable employment, lack of social support, and a history of mental illness. (Setyorini *et al*., 2023) reported that pregnant women with lower education, unplanned pregnancies, and obstetric complications are at heightened risk of psychological distress. (Syam *et al*., 2020)) emphasized that lack of spousal support and household economic insecurity significantly contribute to prenatal depression. Furthermore, (Sari *et al*., 2023) highlighted that low mental health literacy and high levels of social stigma among pregnant women exacerbate delays in seeking professional help, echoing global patterns (Gelaye *et al*., 2016; Glover, 2014). In response to these concerns, the Indonesian Ministry of Health issued a national policy in 2023 mandating mental health screening for all pregnant and postpartum women. The screenings are to be conducted twice during pregnancy (at the first and fifth antenatal care visits) and once during the postpartum period (between 8–28 days after delivery) (Kemenkes RI, 2023). This policy is supported by the development of digital platforms such as SATUSEHAT Mobile and SIMKESWA to enhance technology-based early detection, as well as nationwide training programs for healthcare providers (Kemenkes RI, 2024).

Although research on perinatal mental health in Indonesia has been increasing, studies that systematically synthesize quantitative findings remain limited. A comprehensive review is necessary to identify key risk factors, inform the implementation of national screening policies, and strengthen maternal mental health services at the primary care level. Therefore, this study aims to systematically review quantitative studies published between 2015 and 2024 that examined risk factors associated with perinatal mental health disorders in Indonesia. The findings are expected to inform future research, policy formulation, and clinical practices that support the integration of mental health into maternal care.

Methods

This study is a systematic review aimed at identifying and synthesizing the risk factors associated with perinatal mental health disorders in Indonesia. The synthesis framework adopts the PICO approach (Population, Intervention, Comparison, Outcome), a widely used model in evidence-based health research. The reporting of this systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page *et al*., 2021). A systematic literature search was conducted in three databases: PubMed, Scopus, and Google Scholar. The search was carried out in January 2024, targeting articles published from January 1, 2015, to January 31, 2024, in English, and accessible in full text. The search strategy was developed using the PICO framework. The following keywords and Boolean operators were used: ("perinatal mental health" OR "Maternal mental health") AND ("depression" OR "anxiety") AND ("risk factors") AND ("Indonesia"). Duplicates were removed manually, and all screening was conducted independently by two reviewers.

Studies included in this synthesis met the following inclusion criteria:

Investigated perinatal mental health disorders (depression, anxiety, or both) among pregnant or postpartum women;

- Employed a quantitative research design (cross-sectional, cohort, or case-control);
- Focused on populations within Indonesia;
- Reported data on risk factors or determinants associated with perinatal mental health outcomes;
- Were published between 2015 and 2024, accessible in full-text, peer-reviewed, and sourced from reputable scientific journals indexed in international or national academic databases.

The exclusion criteria were as follows:

- Qualitative studies or other types of secondary literature reviews;
- Studies that did not focus on pregnant or postpartum women;
- Articles that were not available in full-text.

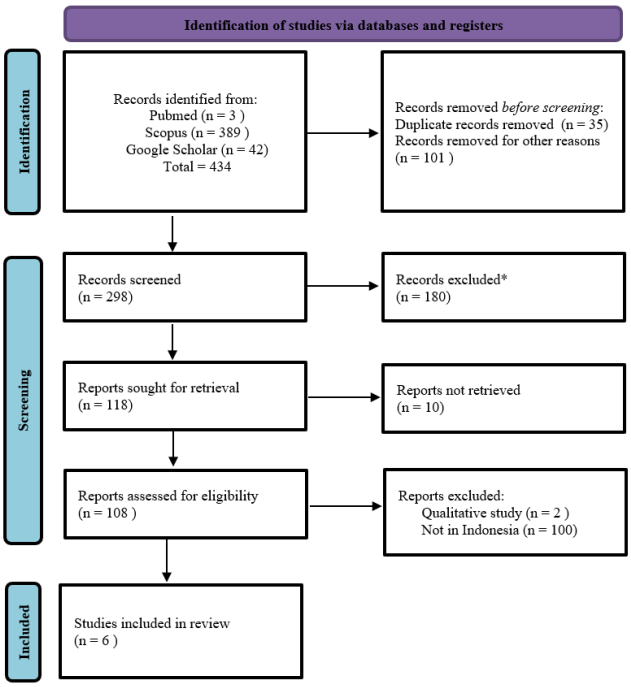
The study selection process followed the PRISMA 2020 flowchart, beginning with the initial identification of 434 articles retrieved from all databases. After removing duplicates and screening titles and abstracts, potentially relevant articles underwent full-text eligibility assessment. Studies that did not meet the inclusion criteria or were duplicate entries were excluded. A total of 6 studies met all inclusion criteria and were included in the final data synthesis.

Data from the six included studies were extracted independently by two reviewers using a standardized data extraction form. Discrepancies were resolved through discussion and consensus. The extracted items included: year of publication, study design, sample size, study location, population characteristics, investigated risk factors, and main findings related to perinatal depression or anxiety. The extracted data were then synthesized using a descriptive thematic approach and organized in both tabular and narrative forms. The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies, which is appropriate for the designs of the included articles. Each study was evaluated independently by two reviewers based on eight criteria, including sample selection, measurement validity, and confounding factors. All studies met at least six of the eight criteria, indicating moderate to high methodological quality. The most common limitations identified were unclear handling of confounding variables and limited information on response rates. Disagreements between reviewers were resolved by discussion.

Result and Discussion

A total of 434 records were identified through systematic searches in PubMed (n = 3), Scopus (n = 389), and Google Scholar (n = 42). After removing 35 duplicate records and 101 records excluded for other reasons (such as irrelevant titles or inaccessible sources), 298 titles and abstracts were screened. Following screening, 118 full-text articles were retrieved for eligibility assessment. Of these, 10 articles were not accessible, and 102 were excluded, with primary reasons including non-Indonesian context (n = 100) and qualitative design (n = 2). In total, 6 studies fulfilled the inclusion criteria and were included in this review. All included studies employed quantitative designs, mostly cross-sectional, and examined risk factors for perinatal depression and/or anxiety. No automation tools were used in the selection process. All screening and eligibility steps were conducted independently by two reviewers through manual assessment.

Following the study selection process illustrated in the PRISMA 2020 flow diagram (Figure 1), a total of six studies were included in the final synthesis. These studies, published between 2015 and 2025, were retrieved from reputable international peer-reviewed journals and predominantly applied quantitative approaches, particularly cross-sectional study designs. To support thematic analysis and comparison, key information was extracted and compiled into a structured table. The table below presents a summary of each included study, covering the title, research design, characteristics of the study population, focus of investigation, and the main outcomes related to



**No automation tools were used; all screening was conducted manually by the reviewers.

Figure 1. PRISMA 2020 Flow Diagram of Study Selection Process

Tables 1. Summary of Included Studies: Study Design, Population, Focus of Investigation, and Key Outcomes

NO	TITLE	STUDY DESAIN	POPULATION	FOCUS OF INVESTIGATION	OUTCOME
1.	Common Mental Disorders and Associated Factors During Pregnancy and the Postpartum Period in Indonesia: An Analysis of Data From the 2018 Basic Health Research (Ariasih *et al*., 2024)	Cross-sectional Survey	Pregnant and postpartum women aged 15–49 years who are or have been married based on RISKESDAS, 2018.	Exposure to risk factors (sociodemographic, health, and obstetric) that may increase the likelihood of experiencing CMDs (Common Mental Disorders)	Significant factors associated with CMDs include sociodemographic (age, education, employment status), health (hypertension history, general health, smoking status, MUAC), and obstetric (obstetric history, pregnancy trimester, abortion history, pregnancy complications). All three domains were significant in postpartum women.
2.	Identifying risk factors of prenatal depression among mothers in Indonesia (Syam *et al*., 2020)	Cross-sectional Study	321 pregnant women with gestational age ≥12 weeks in Makassar, South Sulawesi, Indonesia	Exposure to risk factors (sociodemographic, psychosocial, obstetric, lifestyle, and health) potentially increases prenatal depression	Prenatal anxiety and depression symptoms were significantly associated with husband's education, family income, birth planning, fear of childbirth, planned/ previous C-section, and partner support.

3.	Exploring perinatal mental health in Indonesia: A mixed-method study in Mataram, West Nusa Tenggara (Harahap *et al*., 2024)	Cross-sectional study and ethnographic approach	33 postpartum women within the first month at Babakan Health Center	Exposure to demographic, social & familial, mental health history, obstetric, and environmental & economic risk factors	The history of adolescent mental health disorders showed a significant association with increased risk of PMH issues.
4.	Maternal age as a main factor influencing prenatal distress in Indonesian Primigravida (Ayu *et al*., 2019)	Cross-sectional	A total of 214 primigravida mothers at community health centers in Banten Province, Indonesia, participated in the study	The research examined the influence of maternal age and other factors—such as education level, income, gestational age, social support, history of traumatic experiences, satisfaction with paternal support, and pregnancy planning—on prenatal distress.	The study found that maternal age was the most influential factor affecting stress during pregnancy.
5.	Maternal Factors Influencing Postpartum Depression in Indonesia (Sari *et al*., 2023)	Cross-sectional	251 postpartum women (2–8 weeks) in Bandar Lampung, February–May 2023	Risk factors for postpartum depression (abortion history, previous depression, employment, education, family support)	Abortion history, age, parity, education, prior depression, employment status, and family support were associated with postpartum depression.
6.	Antenatal depression and its associated factors among pregnant women in Jakarta, Indonesia (Misrawati & Afiyanti, 2020)	Cross-sectional study	196 pregnant women aged 20–40 years at Menteng, Senen, and Ciracas Health Centers	196 pregnant women aged 20–40 years at Menteng, Senen, and Ciracas Health Centers	Age, education, employment, parity, gestational age, pregnancy planning, and family type were not significantly correlated. The history of depression was significantly correlated with antenatal depression.

perinatal mental health disorders.

This systematic review synthesized findings from six quantitative studies conducted in Indonesia between 2015 and 2024. The results demonstrate that perinatal mental health disorders, particularly depression and anxiety, are consistently associated with sociodemographic (e.g., young maternal age, low education), psychosocial (e.g., lack of partner support), obstetric (e.g., history of complications), and psychological factors (e.g., previous depression). These findings are consistent with global patterns reported in the systematic review by Fisher *et al*. (2012), which highlighted a significantly higher prevalence of perinatal mental disorders in low- and middle-income countries, including Indonesia. Consistently, factors such as young maternal age, low educational attainment, unstable employment, and lack of social support emerged as key predictors of perinatal mental health disorders(Ariasih *et al*., 2024; Ayu *et al*., 2019; Misrawati & Afiyanti, 2020)

Maternal age, particularly adolescent pregnancy, indicates a greater vulnerability to stress and depression. A study in Indonesia

found that younger mothers were more likely to experience prenatal distress than older mothers (Ayu *et al*., 2019). This is reinforced by the findings of (Jose Tilman *et al*., 2024), who associated adolescent pregnancy with more severe postpartum depression and prolonged stress affecting child well-being. Similarly, Mollborn & Morningstar (2009), emphasized that adolescent pregnancy consistently increases the risk of poor mental health outcomes due to social pressure, stigma, and limited access to support services. Expanding on these findings, a recent literature review by Lesinskienė *et al*. (2025) underscores that adolescent pregnancy poses substantial mental health risks, particularly in low- and middle-income settings. Pregnant adolescents experience disproportionately high rates of depression, suicidal ideation, low self-esteem, substance use, and anxiety. The review highlights the urgency for comprehensive, long-term solutions and multidisciplinary approaches that can improve both the mental and physical health support available to this vulnerable group. These findings collectively point to the necessity of targeted interventions that are developmentally appropriate, culturally sensitive, and embedded within the broader reproductive and maternal healthcare systems.

Low educational attainment also emerged as a consistent risk factor for perinatal mental disorders. Setyorini *et al*. (2023) found that pregnant women with lower levels of education had a limited understanding of mental health information, resulting in delays in help-seeking. Gelaye *et al*. (2016) similarly, we found that low education exacerbated the risk of prenatal depression in LMICs, largely due to limited health literacy. In China. Zhang *et al*. (2025) identified health literacy as a key mediator between education level and prenatal depression—women with higher education were less likely to experience depression. Educational disadvantage is also linked to limited access to care, economic vulnerability, and greater dependency on partners.

Beyond age and education, social support plays a critical protective role in mitigating perinatal mental health disorders. In Indonesia, Syam *et al*. (2020) demonstrated that lack of partner support was significantly associated with prenatal depression. This finding aligns with a longitudinal study by Leigh & Milgrom (2008), which reported that emotional support from partners and family effectively reduced the risk of developing postpartum depression. Parallel findings in Vietnam (Nguyen *et al*., 2021) and Pakistan (Waqas *et al*., 2020) further emphasize the importance of social support in reducing the risk of depression among pregnant women in low-resource settings. More recently, Umuziga *et al*. (2023) found that insufficient social support from partners and family significantly increased postnatal depressive symptoms among mothers in Rwanda. Likewise, a prospective cohort study in Australia by Bedaso *et al*. (2021)revealed that pregnant women with lower levels of emotional and informational support had significantly higher odds of experiencing antenatal depressive symptoms. Collectively, these studies underscore the essential role of social support—whether emotional, instrumental, or informational—as a protective factor against perinatal mental health problems. Integrating psychosocial screening into routine antenatal care and strengthening family- and community-based support systems are crucial strategies to improve maternal mental health outcomes, particularly in low- and middle-income countries.

In addition, Harahap *et al*. (2024), through an ethnographic approach, highlighted adolescent mental health history as a significant risk factor for postpartum mental health disorders. This is consistent with findings from Rees *et al*. (2016) in Timor-Leste, which revealed that exposure to intimate partner violence (IPV) and past trauma significantly increased the risk of depression. This shows that mental health vulnerabilities can persist over time, and adolescence is a critical period for identifying early mental health risks. If left untreated, these problems can reappear or worsen during stressful life events—such as childbirth and early parenting.

Complementing these perspectives, Maulina *et al*., (2025) contributed additional insight by examining how psychological factors affect not only emotional well-being but also behavioral outcomes. In a cross-sectional study involving 224 pregnant women in Indonesia,

they found that maternal-fetal attachment and maternal prenatal depression were the strongest predictors of adopting a health-promoting lifestyle. The study revealed that stronger maternal-fetal attachment was associated with better nutrition, physical activity, and stress management, whereas prenatal depression was negatively correlated with those behaviors. This finding extends the discussion beyond mental health outcomes and suggests that psychological well-being directly influences the mother's capacity to engage in protective health behaviors during pregnancy.

The strength of this synthesis lies in its broad geographic representation across Indonesia, the use of nationally representative datasets such as RISKESDAS (Ariasih *et al*., 2024), and the integration of both quantitative and qualitative approaches. However, most of the studies employed a cross-sectional design, collecting data at a single point in time. Consequently, they are limited in establishing causal relationships. Although associations were observed between risk factors (e.g., young age, low education) and mental health disorders, these studies do not provide definitive evidence of causality. Longitudinal research or randomized controlled trials (RCTs) are needed to draw stronger causal inferences. While the review offers important insights, it is not without limitations. All included studies applied cross-sectional designs, which limit causal inference. Moreover, no formal meta-analysis was performed due to methodological heterogeneity in measurement tools and population characteristics.

These findings underscore the urgency of integrating routine mental health screening into Indonesia's maternal and child health services. In line with WHO recommendations (WHO, 2022), the Indonesian Ministry of Health has issued a national policy mandating annual mental health screening for the general population, and specifically three screenings for pregnant and postpartum women: twice during pregnancy (at the first and fifth antenatal visits) and once postpartum (between 8–28 days after delivery). Implementation of this policy has been supported by the development of digital platforms such as SATUSEHAT Mobile and SIMKESWA, which facilitate early detection of mental health issues in primary care. The Ministry has also initiated mental health screening training programs for healthcare providers across all provinces, demonstrating a strong government commitment to strengthening perinatal mental health services nationwide.

The practical implications of these findings point to the need for expanding primary healthcare provider training in early detection, initial management, and referral for perinatal mental health disorders. Integration with national programs such as "Gerakan Masyarakat Hidup Sehat (GERMAS)" offers opportunities to broaden community-based mental health promotion more systematically. Looking ahead, more longitudinal research and RCTs are needed to evaluate the effectiveness of various intervention models—both community-based and technology-driven—in preventing and addressing perinatal mental health disorders. Participatory qualitative studies are also crucial to better understand the lived emotional experiences of pregnant and postpartum women within Indonesia's cultural context.

Conclusion

This systematic review identified consistent risk factors contributing to perinatal mental health disorders in Indonesia, including young maternal age, low educational attainment, inadequate social support, and a history of mental illness. These findings underscore the urgent need to integrate routine mental health screening into maternal care, strengthen health worker capacity, and promote culturally sensitive interventions. Future studies employing longitudinal or interventional designs are essential to establish causal relationships and inform effective, scalable mental health strategies for Indonesian women during the perinatal period.

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KEMAS 21 (2) (2025) 369-377

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Perinatal Mental Health Disorders in Indonesia: A Systematic Review of Quantitative Studies (2015–2024)

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Article Info

Article History:
Submitted: June 2025
Accepted: September 2025
Published: October 2025

Keywords:
perinatal mental health; depression, anxiety; risk factors; maternal health; Indonesia

DOI
https://doi.org/10.15294/kemas.v21i2.26267

Abstract

Perinatal mental health disorders, especially depression and anxiety, are prevalent among women in low- and middle-income countries (LMICs), including Indonesia. These conditions can affect both maternal well-being and child development. This systematic review aimed to identify and synthesize key risk factors associated with perinatal mental health disorders among women in Indonesia. A systematic search was conducted in PubMed, Scopus, and Google Scholar for quantitative studies published between 2015 and 2024. Inclusion criteria included studies involving pregnant or postpartum women in Indonesia, using quantitative designs, and reporting on risk factors for depression and/or anxiety. The review followed PRISMA 2020 guidelines. Data extraction and screening were conducted manually by reviewers. Out of 434 identified records, six studies met the inclusion criteria. Most employed cross-sectional designs focused on sociodemographic, psychosocial, obstetric, and psychological factors. Common risk factors included young maternal age, low education, unstable employment, lack of social support, and history of mental illness. Several studies also identified low mental health literacy and poor maternal-fetal attachment as contributing factors. The included studies were mostly cross-sectional, limiting causal inference. This review highlights the need for routine mental health screening, greater provider training, and community-based interventions in maternal health care. Future research should prioritize longitudinal designs and assess the effectiveness of policy implementation

Introduction

Perinatal mental health disorders, encompassing the period from pregnancy to one year postpartum, have become a major concern in global public health (Gelaye *et al*., 2016; Howard & Khalifeh, 2020). Disorders such as perinatal depression and anxiety can negatively impact not only maternal well-being but also child development, including emotional bonding, physical growth, mental health, and cognitive outcomes. These conditions are particularly prevalent in low- and middle-income countries (LMICs), where healthcare resources and access to mental health services remain limited. Without early detection and appropriate intervention, the consequences of these disorders can persist across generations and increase long-term public health burdens (Glover, 2014; WHO, 2022).

Globally, despite the high prevalence of perinatal mental disorders, detection and management rates remain alarmingly low, particularly in low- and middle-income countries (Howard & Khalifeh, 2020). Key barriers include limited capacity within primary healthcare services, insufficient training for health workers in mental health screening, pervasive social stigma surrounding mental illness, and low mental health literacy among pregnant women and their families (Shorey *et al*., 2018; WHO, 2022). To address these gaps, the World Health Organization (WHO, 2022)

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pISSN 1858-1196
eISSN 2355-3596

recommends the routine integration of mental health screening into antenatal and postnatal care services. Some countries have responded with national policies: NHS (National Health Service) England, through its Long Term Plan, has committed to expanding perinatal mental health services up to two years postpartum (NHS England, 2023), while Australia enforces its National Perinatal Mental Health Guidelines, advocating for at least one screening during pregnancy and another in the postpartum period (Gidget Foundation Australia, 2023).

Similar challenges are observed in Indonesia. National data indicate that the prevalence of Common Mental Disorders (CMD) among pregnant and postpartum women reaches 8.4%, yet most cases go undetected in primary care settings (Ariasih *et al*., 2024). A study in Jakarta Misrawati & Afiyanti, (2020) found that over 25% of pregnant women experienced antenatal depressive symptoms, although only a small proportion received counseling or further intervention. The absence of routine screening systems, limited training among health professionals, and persistent mental health stigma contribute to poor early detection rates.

Numerous studies in Indonesia have identified consistent risk factors associated with perinatal mental health disorders. These include young maternal age, low educational attainment, unstable employment, lack of social support, and a history of mental illness. (Setyorini *et al*., 2023) reported that pregnant women with lower education, unplanned pregnancies, and obstetric complications are at heightened risk of psychological distress. (Syam *et al*., 2020)) emphasized that lack of spousal support and household economic insecurity significantly contribute to prenatal depression. Furthermore, (Sari *et al*., 2023) highlighted that low mental health literacy and high levels of social stigma among pregnant women exacerbate delays in seeking professional help, echoing global patterns (Gelaye *et al*., 2016; Glover, 2014). In response to these concerns, the Indonesian Ministry of Health issued a national policy in 2023 mandating mental health screening for all pregnant and postpartum women. The screenings are to be conducted twice during pregnancy (at the first and fifth antenatal care visits) and once during the postpartum period (between 8–28 days after delivery) (Kemenkes RI, 2023). This policy is supported by the development of digital platforms such as SATUSEHAT Mobile and SIMKESWA to enhance technology-based early detection, as well as nationwide training programs for healthcare providers (Kemenkes RI, 2024).

Although research on perinatal mental health in Indonesia has been increasing, studies that systematically synthesize quantitative findings remain limited. A comprehensive review is necessary to identify key risk factors, inform the implementation of national screening policies, and strengthen maternal mental health services at the primary care level. Therefore, this study aims to systematically review quantitative studies published between 2015 and 2024 that examined risk factors associated with perinatal mental health disorders in Indonesia. The findings are expected to inform future research, policy formulation, and clinical practices that support the integration of mental health into maternal care.

Methods

This study is a systematic review aimed at identifying and synthesizing the risk factors associated with perinatal mental health disorders in Indonesia. The synthesis framework adopts the PICO approach (Population, Intervention, Comparison, Outcome), a widely used model in evidence-based health research. The reporting of this systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page *et al*., 2021). A systematic literature search was conducted in three databases: PubMed, Scopus, and Google Scholar. The search was carried out in January 2024, targeting articles published from January 1, 2015, to January 31, 2024, in English, and accessible in full text. The search strategy was developed using the PICO framework. The following keywords and Boolean operators were used: ("perinatal mental health" OR "Maternal mental health") AND ("depression" OR "anxiety") AND ("risk factors") AND ("Indonesia"). Duplicates were removed manually, and all screening was conducted independently by two reviewers.

Studies included in this synthesis met the following inclusion criteria:

Investigated perinatal mental health disorders (depression, anxiety, or both) among pregnant or postpartum women;

- Employed a quantitative research design (cross-sectional, cohort, or case-control);
- Focused on populations within Indonesia;
- Reported data on risk factors or determinants associated with perinatal mental health outcomes;
- Were published between 2015 and 2024, accessible in full-text, peer-reviewed, and sourced from reputable scientific journals indexed in international or national academic databases.

The exclusion criteria were as follows:

- Qualitative studies or other types of secondary literature reviews;
- Studies that did not focus on pregnant or postpartum women;
- Articles that were not available in full-text.

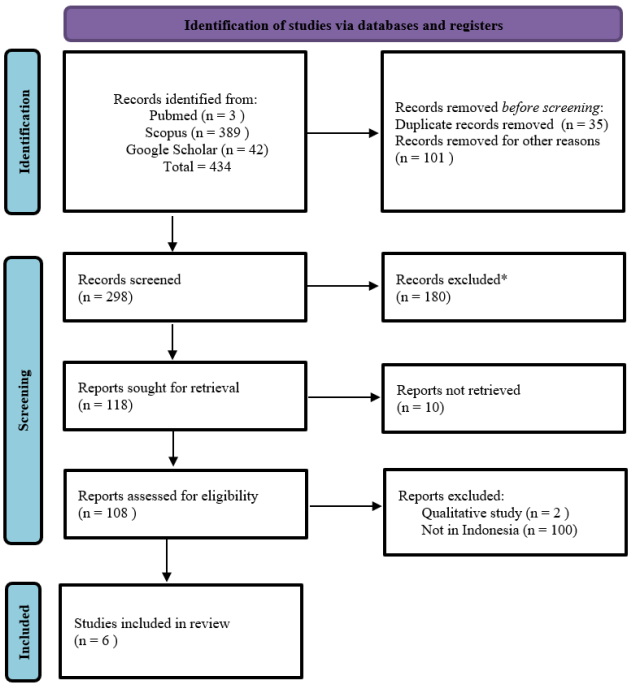
The study selection process followed the PRISMA 2020 flowchart, beginning with the initial identification of 434 articles retrieved from all databases. After removing duplicates and screening titles and abstracts, potentially relevant articles underwent full-text eligibility assessment. Studies that did not meet the inclusion criteria or were duplicate entries were excluded. A total of 6 studies met all inclusion criteria and were included in the final data synthesis.

Data from the six included studies were extracted independently by two reviewers using a standardized data extraction form. Discrepancies were resolved through discussion and consensus. The extracted items included: year of publication, study design, sample size, study location, population characteristics, investigated risk factors, and main findings related to perinatal depression or anxiety. The extracted data were then synthesized using a descriptive thematic approach and organized in both tabular and narrative forms. The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies, which is appropriate for the designs of the included articles. Each study was evaluated independently by two reviewers based on eight criteria, including sample selection, measurement validity, and confounding factors. All studies met at least six of the eight criteria, indicating moderate to high methodological quality. The most common limitations identified were unclear handling of confounding variables and limited information on response rates. Disagreements between reviewers were resolved by discussion.

Result and Discussion

A total of 434 records were identified through systematic searches in PubMed (n = 3), Scopus (n = 389), and Google Scholar (n = 42). After removing 35 duplicate records and 101 records excluded for other reasons (such as irrelevant titles or inaccessible sources), 298 titles and abstracts were screened. Following screening, 118 full-text articles were retrieved for eligibility assessment. Of these, 10 articles were not accessible, and 102 were excluded, with primary reasons including non-Indonesian context (n = 100) and qualitative design (n = 2). In total, 6 studies fulfilled the inclusion criteria and were included in this review. All included studies employed quantitative designs, mostly cross-sectional, and examined risk factors for perinatal depression and/or anxiety. No automation tools were used in the selection process. All screening and eligibility steps were conducted independently by two reviewers through manual assessment.

Following the study selection process illustrated in the PRISMA 2020 flow diagram (Figure 1), a total of six studies were included in the final synthesis. These studies, published between 2015 and 2025, were retrieved from reputable international peer-reviewed journals and predominantly applied quantitative approaches, particularly cross-sectional study designs. To support thematic analysis and comparison, key information was extracted and compiled into a structured table. The table below presents a summary of each included study, covering the title, research design, characteristics of the study population, focus of investigation, and the main outcomes related to



**No automation tools were used; all screening was conducted manually by the reviewers.

Figure 1. PRISMA 2020 Flow Diagram of Study Selection Process

Tables 1. Summary of Included Studies: Study Design, Population, Focus of Investigation, and Key Outcomes

NO	TITLE	STUDY DESAIN	POPULATION	FOCUS OF INVESTIGATION	OUTCOME
1.	Common Mental Disorders and Associated Factors During Pregnancy and the Postpartum Period in Indonesia: An Analysis of Data From the 2018 Basic Health Research (Ariasih *et al*., 2024)	Cross-sectional Survey	Pregnant and postpartum women aged 15–49 years who are or have been married based on RISKESDAS, 2018.	Exposure to risk factors (sociodemographic, health, and obstetric) that may increase the likelihood of experiencing CMDs (Common Mental Disorders)	Significant factors associated with CMDs include sociodemographic (age, education, employment status), health (hypertension history, general health, smoking status, MUAC), and obstetric (obstetric history, pregnancy trimester, abortion history, pregnancy complications). All three domains were significant in postpartum women.
2.	Identifying risk factors of prenatal depression among mothers in Indonesia (Syam *et al*., 2020)	Cross-sectional Study	321 pregnant women with gestational age ≥12 weeks in Makassar, South Sulawesi, Indonesia	Exposure to risk factors (sociodemographic, psychosocial, obstetric, lifestyle, and health) potentially increases prenatal depression	Prenatal anxiety and depression symptoms were significantly associated with husband's education, family income, birth planning, fear of childbirth, planned/ previous C-section, and partner support.

3.	Exploring perinatal mental health in Indonesia: A mixed-method study in Mataram, West Nusa Tenggara (Harahap *et al*., 2024)	Cross-sectional study and ethnographic approach	33 postpartum women within the first month at Babakan Health Center	Exposure to demographic, social & familial, mental health history, obstetric, and environmental & economic risk factors	The history of adolescent mental health disorders showed a significant association with increased risk of PMH issues.
4.	Maternal age as a main factor influencing prenatal distress in Indonesian Primigravida (Ayu *et al*., 2019)	Cross-sectional	A total of 214 primigravida mothers at community health centers in Banten Province, Indonesia, participated in the study	The research examined the influence of maternal age and other factors—such as education level, income, gestational age, social support, history of traumatic experiences, satisfaction with paternal support, and pregnancy planning—on prenatal distress.	The study found that maternal age was the most influential factor affecting stress during pregnancy.
5.	Maternal Factors Influencing Postpartum Depression in Indonesia (Sari *et al*., 2023)	Cross-sectional	251 postpartum women (2–8 weeks) in Bandar Lampung, February–May 2023	Risk factors for postpartum depression (abortion history, previous depression, employment, education, family support)	Abortion history, age, parity, education, prior depression, employment status, and family support were associated with postpartum depression.
6.	Antenatal depression and its associated factors among pregnant women in Jakarta, Indonesia (Misrawati & Afiyanti, 2020)	Cross-sectional study	196 pregnant women aged 20–40 years at Menteng, Senen, and Ciracas Health Centers	196 pregnant women aged 20–40 years at Menteng, Senen, and Ciracas Health Centers	Age, education, employment, parity, gestational age, pregnancy planning, and family type were not significantly correlated. The history of depression was significantly correlated with antenatal depression.

perinatal mental health disorders.

This systematic review synthesized findings from six quantitative studies conducted in Indonesia between 2015 and 2024. The results demonstrate that perinatal mental health disorders, particularly depression and anxiety, are consistently associated with sociodemographic (e.g., young maternal age, low education), psychosocial (e.g., lack of partner support), obstetric (e.g., history of complications), and psychological factors (e.g., previous depression). These findings are consistent with global patterns reported in the systematic review by Fisher *et al*. (2012), which highlighted a significantly higher prevalence of perinatal mental disorders in low- and middle-income countries, including Indonesia. Consistently, factors such as young maternal age, low educational attainment, unstable employment, and lack of social support emerged as key predictors of perinatal mental health disorders(Ariasih *et al*., 2024; Ayu *et al*., 2019; Misrawati & Afiyanti, 2020)

Maternal age, particularly adolescent pregnancy, indicates a greater vulnerability to stress and depression. A study in Indonesia

found that younger mothers were more likely to experience prenatal distress than older mothers (Ayu *et al*., 2019). This is reinforced by the findings of (Jose Tilman *et al*., 2024), who associated adolescent pregnancy with more severe postpartum depression and prolonged stress affecting child well-being. Similarly, Mollborn & Morningstar (2009), emphasized that adolescent pregnancy consistently increases the risk of poor mental health outcomes due to social pressure, stigma, and limited access to support services. Expanding on these findings, a recent literature review by Lesinskienė *et al*. (2025) underscores that adolescent pregnancy poses substantial mental health risks, particularly in low- and middle-income settings. Pregnant adolescents experience disproportionately high rates of depression, suicidal ideation, low self-esteem, substance use, and anxiety. The review highlights the urgency for comprehensive, long-term solutions and multidisciplinary approaches that can improve both the mental and physical health support available to this vulnerable group. These findings collectively point to the necessity of targeted interventions that are developmentally appropriate, culturally sensitive, and embedded within the broader reproductive and maternal healthcare systems.

Low educational attainment also emerged as a consistent risk factor for perinatal mental disorders. Setyorini *et al*. (2023) found that pregnant women with lower levels of education had a limited understanding of mental health information, resulting in delays in help-seeking. Gelaye *et al*. (2016) similarly, we found that low education exacerbated the risk of prenatal depression in LMICs, largely due to limited health literacy. In China. Zhang *et al*. (2025) identified health literacy as a key mediator between education level and prenatal depression—women with higher education were less likely to experience depression. Educational disadvantage is also linked to limited access to care, economic vulnerability, and greater dependency on partners.

Beyond age and education, social support plays a critical protective role in mitigating perinatal mental health disorders. In Indonesia, Syam *et al*. (2020) demonstrated that lack of partner support was significantly associated with prenatal depression. This finding aligns with a longitudinal study by Leigh & Milgrom (2008), which reported that emotional support from partners and family effectively reduced the risk of developing postpartum depression. Parallel findings in Vietnam (Nguyen *et al*., 2021) and Pakistan (Waqas *et al*., 2020) further emphasize the importance of social support in reducing the risk of depression among pregnant women in low-resource settings. More recently, Umuziga *et al*. (2023) found that insufficient social support from partners and family significantly increased postnatal depressive symptoms among mothers in Rwanda. Likewise, a prospective cohort study in Australia by Bedaso *et al*. (2021)revealed that pregnant women with lower levels of emotional and informational support had significantly higher odds of experiencing antenatal depressive symptoms. Collectively, these studies underscore the essential role of social support—whether emotional, instrumental, or informational—as a protective factor against perinatal mental health problems. Integrating psychosocial screening into routine antenatal care and strengthening family- and community-based support systems are crucial strategies to improve maternal mental health outcomes, particularly in low- and middle-income countries.

In addition, Harahap *et al*. (2024), through an ethnographic approach, highlighted adolescent mental health history as a significant risk factor for postpartum mental health disorders. This is consistent with findings from Rees *et al*. (2016) in Timor-Leste, which revealed that exposure to intimate partner violence (IPV) and past trauma significantly increased the risk of depression. This shows that mental health vulnerabilities can persist over time, and adolescence is a critical period for identifying early mental health risks. If left untreated, these problems can reappear or worsen during stressful life events—such as childbirth and early parenting.

Complementing these perspectives, Maulina *et al*., (2025) contributed additional insight by examining how psychological factors affect not only emotional well-being but also behavioral outcomes. In a cross-sectional study involving 224 pregnant women in Indonesia,

they found that maternal-fetal attachment and maternal prenatal depression were the strongest predictors of adopting a health-promoting lifestyle. The study revealed that stronger maternal-fetal attachment was associated with better nutrition, physical activity, and stress management, whereas prenatal depression was negatively correlated with those behaviors. This finding extends the discussion beyond mental health outcomes and suggests that psychological well-being directly influences the mother's capacity to engage in protective health behaviors during pregnancy.

The strength of this synthesis lies in its broad geographic representation across Indonesia, the use of nationally representative datasets such as RISKESDAS (Ariasih *et al*., 2024), and the integration of both quantitative and qualitative approaches. However, most of the studies employed a cross-sectional design, collecting data at a single point in time. Consequently, they are limited in establishing causal relationships. Although associations were observed between risk factors (e.g., young age, low education) and mental health disorders, these studies do not provide definitive evidence of causality. Longitudinal research or randomized controlled trials (RCTs) are needed to draw stronger causal inferences. While the review offers important insights, it is not without limitations. All included studies applied cross-sectional designs, which limit causal inference. Moreover, no formal meta-analysis was performed due to methodological heterogeneity in measurement tools and population characteristics.

These findings underscore the urgency of integrating routine mental health screening into Indonesia's maternal and child health services. In line with WHO recommendations (WHO, 2022), the Indonesian Ministry of Health has issued a national policy mandating annual mental health screening for the general population, and specifically three screenings for pregnant and postpartum women: twice during pregnancy (at the first and fifth antenatal visits) and once postpartum (between 8–28 days after delivery). Implementation of this policy has been supported by the development of digital platforms such as SATUSEHAT Mobile and SIMKESWA, which facilitate early detection of mental health issues in primary care. The Ministry has also initiated mental health screening training programs for healthcare providers across all provinces, demonstrating a strong government commitment to strengthening perinatal mental health services nationwide.

The practical implications of these findings point to the need for expanding primary healthcare provider training in early detection, initial management, and referral for perinatal mental health disorders. Integration with national programs such as "Gerakan Masyarakat Hidup Sehat (GERMAS)" offers opportunities to broaden community-based mental health promotion more systematically. Looking ahead, more longitudinal research and RCTs are needed to evaluate the effectiveness of various intervention models—both community-based and technology-driven—in preventing and addressing perinatal mental health disorders. Participatory qualitative studies are also crucial to better understand the lived emotional experiences of pregnant and postpartum women within Indonesia's cultural context.

Conclusion

This systematic review identified consistent risk factors contributing to perinatal mental health disorders in Indonesia, including young maternal age, low educational attainment, inadequate social support, and a history of mental illness. These findings underscore the urgent need to integrate routine mental health screening into maternal care, strengthen health worker capacity, and promote culturally sensitive interventions. Future studies employing longitudinal or interventional designs are essential to establish causal relationships and inform effective, scalable mental health strategies for Indonesian women during the perinatal period.

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KEMAS 21 (2) (2025) 392-401

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Brand Image as a Determinant of Patient Decision-Making in Inpatient Healthcare Utilization

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Article Info

Article History:
Submitted: May 2025
Accepted: September 2025
Published: October 2025

Keywords:
Brand image; patient decision-making; inpatient services; hospital management; healthcare marketing

DOI
https://doi.org/10.15294/kemas.v21i2.25500

Abstract

Healthcare has evolved from provider-centered to consumer-oriented models, making brand image crucial in patient decision-making. However, systematic examination of this relationship in developing country healthcare contexts remains limited. This study investigated how brand image dimensions (corporate identity, physical environment, contact personnel, service offerings, and corporate individuality) influence patient decisions for inpatient services at Nahdlatul Ulama Hospital, Tuban, Indonesia. A quantitative cross-sectional study from January to March 2023 using structured questionnaires from 268 inpatients selected through purposive sampling. Brand image dimensions and patient decision-making were measured using 5-point Likert scales. Analysis included descriptive statistics, Spearman's correlation, and multiple linear regression. All five dimensions collectively influenced patient decision-making ($F=42.990$, $p<0.001$), explaining 45.1% of variance. Bivariate analysis showed significant correlations for all dimensions, with physical environment ($rho=0.456$, $p<0.001$) and corporate identity ($rho=0.399$, $p<0.001$) strongest. However, multivariate analysis revealed only three dimensions independently influenced decisions: service offerings ($\beta=0.318$, $p<0.001$), contact personnel ($\beta=0.184$, $p=0.024$), and corporate individuality ($\beta=0.115$, $p=0.030$). Brand image significantly influences inpatient healthcare decisions, with service offerings, contact personnel, and corporate individuality most influential. Healthcare facilities should develop comprehensive brand strategies emphasizing service quality, patient-staff interactions, and aligned corporate values, highlighting human elements over physical infrastructure.

Introduction

In the increasingly competitive global healthcare landscape, hospitals worldwide are recognizing the strategic imperative of developing a distinctive brand image to influence patient decision-making processes (Kemp *et al*., 2014; Maulana & Ayuningtyas, 2023; Pakaya *et al*., 2024). The healthcare sector has undergone a paradigm shift from its traditional provider-centered model to a more consumer-oriented approach, transforming patients into discerning healthcare consumers with evolving expectations and preferences (Büyükdağ, 2021; Górska-Warsewicz, 2022; Wartiningsih *et al*., 2022). This transformation necessitates sophisticated branding strategies that effectively communicate value propositions and differentiate healthcare institutions in an increasingly saturated market. This study is anchored in two complementary theoretical frameworks: the Brand Equity Model (Aaker, 1991) and the Healthcare Service Quality Model (Padma *et al*., 2010). Aaker's Brand Equity Model posits that brand equity consists of four key dimensions: brand awareness, brand associations, perceived quality, and brand loyalty. In healthcare contexts, these dimensions translate to institutional recognition, service associations, care quality conception, and patient retention. The Healthcare Service

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pISSN 1858-1196
eISSN 2355-3596

Quality Model complements this framework by emphasizing that patient perceptions of service quality derive from both technical (clinical outcomes, professional competence) and functional aspects (service delivery process, interpersonal interactions).

These theoretical models together suggest that healthcare brand image functions as a cognitive schema through which patients interpret and evaluate their healthcare experiences, subsequently influencing decision-making. This study operationalizes this framework through Wu's (2011) five dimensions of hospital brand image: corporate identity, physical environment, contact personnel, service offerings, and corporate individuality. These dimensions collectively shape patient cognitive and affective responses, which ultimately determine healthcare utilization decisions. Brand image—defined as the constellation of impressions, beliefs, and perceptions stakeholders hold about an organization—has emerged as a critical determinant in patient healthcare decisions (Ackovska *et al*., 2020; Kotler & Keller, 2016). Within healthcare settings specifically, this multidimensional construct encompasses corporate identity, physical environment, contact personnel, service offerings, and corporate individuality (Fairiska & Sulistiadi, 2024; Wu, 2011). These dimensions collectively shape patient perceptions of institutional quality and reliability, subsequently influencing their healthcare utilization patterns (Shabbir *et al*., 2010; Toreh & Wuisan, 2024).

The relationship between brand image and patient trust has been established as particularly significant, with recent research demonstrating that patients frequently equate a robust brand image with perceptions of superior care quality and institutional reliability (Maulana & Ayuningtyas, 2023). This perception-based assessment becomes pivotal in patient decision-making processes, particularly for inpatient services where patients commit to extended care relationships (Sayiram *et al*., 2022). Moreover, scholarly evidence indicates that a well-established brand image provides healthcare institutions with sustainable competitive advantages, fostering patient loyalty and generating positive word-of-mouth recommendations (Fairiska & Sulistiadi, 2024; Toreh & Wuisan, 2024). While the relationship between brand image and consumer behavior has been extensively investigated across retail, hospitality, and financial service sectors (Sürücü *et al*., 2019), systematic examination of this relationship within healthcare contexts remains comparatively limited, particularly in developing countries and regional healthcare markets (Rosyida *et al*., 2025). This research gap is particularly evident in studies examining how brand image influences patient decision-making for inpatient services in non-urban healthcare institutions operating within emerging economies (Stevany *et al*., 2024; Tahir *et al*., 2024).

Indonesia's healthcare ecosystem presents a compelling research context, having experienced substantial structural and competitive evolution in recent years, accompanied by escalating patient expectations for quality care (Muin *et al*., 2024). Regional healthcare providers, such as Nahdlatul Ulama Hospital in Tuban, face distinctive challenges in establishing compelling brand identities while competing with larger urban medical centers that typically command greater resources and broader recognition. These regional institutions must leverage their brand image strategically to attract and retain patients within their service communities, balancing aspirational brand promises with consistent service delivery capabilities (Stevany *et al*., 2024). This study aims to investigate the influence of brand image on patient decisions to utilize inpatient healthcare services at Nahdlatul Ulama Hospital in Tuban, Indonesia, offering findings with potential global applicability. Specifically, the research systematically examines how five fundamental dimensions of brand image—corporate identity, physical environment, contact personnel, service offerings, and corporate individuality—affect patient choice and utilization of inpatient services. Through rigorous empirical analysis, this study seeks to provide evidence-based insights that can inform strategic marketing decisions and operational improvements within regional healthcare facilities internationally.

The findings from this investigation carry significant implications for healthcare

administrators, marketers, and policymakers across global healthcare systems. By identifying the specific brand image components that most strongly influence patient decision-making, healthcare institutions can optimize resource allocation to enhance market positioning and improve patient satisfaction metrics. Additionally, this study contributes meaningfully to the evolving body of literature on healthcare marketing by examining these relationships within the context of a regional hospital in Indonesia, thus addressing a significant gap in current international healthcare branding research (Pilny & Mennicken, 2015). This study examines the extent to which brand image influences patients' decisions to utilize inpatient healthcare services at Nahdlatul Ulama Hospital in Tuban and explores its broader implications for regional healthcare institutions globally. The purpose is to examine how brand image affects patient decision-making, generating insights applicable to similar healthcare contexts worldwide. Specifically, the study aims to identify and evaluate key components of brand image—such as corporate identity, physical environment, contact personnel, service offerings, and corporate individuality—within the hospital, and assess their relevance to global healthcare branding practices. It also seeks to explore the factors that influence patients' decisions to access inpatient care, considering potential cross-cultural differences in healthcare behavior. Furthermore, the research analyzes the relationship between brand image and patient decision-making, with the intention of developing a conceptual framework that can be tested and adapted in different healthcare systems. Finally, the study comes up with evidence-based recommendations to support effective brand image management in regional healthcare institutions facing similar competitive challenges across international settings.

Method

This quantitative cross-sectional study was conducted from January to March 2023 at Nahdlatul Ulama Hospital in Tuban, Indonesia. The hospital was selected as it represents a facility with a distinctive brand identity, serving a diverse patient population. The target population comprised inpatient service users at Nahdlatul Ulama Hospital Tuban, with 816 average annual admissions in 2022. The sample size was calculated using Slovin's formula with 5% margin of error, yielding a minimum requirement of 268 participants. Purposive sampling was employed to select participants meeting the inclusion criteria: patients admitted for at least two days, fully conscious, providing informed consent, and literate. Exclusion criteria included patients with fluctuating consciousness levels and mental disorder diagnoses.

To mitigate selection bias, recruitment occurred across all inpatient departments on different admission days, with trained research assistants approaching eligible patients systematically. The independent variable was brand image measured across five dimensions: corporate identity (hospital characteristics, name, logo, pricing), physical environment (location, facilities, building adequacy, cleanliness), contact personnel (staff interactions), service offering (service quality), and corporate individuality (Islamic values, spiritual care). The dependent variable was the patient's decision to utilize inpatient services.

Data were collected using structured questionnaires with 5-point Likert scales. The questionnaire comprised validated items for corporate identity (6 items), physical environment (6 items), contact personnel (6 items), service offering (9 items), corporate individuality (6 items), and healthcare utilization decision (6 items). Scores were categorized as "Good" (at or above median) or "Poor" (below median). Statistical analysis used IBM SPSS Statistics software with three stages: descriptive statistics for demographic profiling, Spearman's rank correlation for bivariate relationships ($\alpha = 0.05$), and multiple linear regression for multivariate analysis to assess simultaneous and individual effects of brand image dimensions on healthcare utilization decisions.

Result and Discussion

This cross-sectional study was conducted from February 2 to March 31, 2023, at Nahdlatul Ulama Hospital in Tuban. Data were collected

TABLE 1. Sociodemographic Characteristics of Respondents (N=268)

Characteristics	Categories	f	%
Age (years)	17-25 (Young adult)	109	40.7
	25.1-45 (Adult)	148	55.2
	>45.1 (Elderly)	11	4.1
Gender	Male	124	46.3
	Female	144	53.7
Education Level	No education	13	4.9
	Primary education	58	21.6
	Secondary education	105	39.2
	Higher education	92	34.3
Occupation	Unemployed	73	27.2
	Self-employed	76	28.4
	Private employee	105	39.2
	Civil servant	14	5.2
Monthly Income (IDR)	2,000,000-3,000,000	114	42.5
	3,000,001-4,000,000	107	39.9
	4,000,001-5,000,000	31	11.6
	5,000,001-6,000,000	12	4.5
	>6,000,001	4	1.5
Reason for Hospitalization	Doctor's referral	15	5.6
	Self-decision	238	88.8
	Doctor referral	2	0.7
	Health center referral	13	4.9

Source: (Author Primary Data, 2022)

TABLE 2. Univariate Analysis of Brand Image Components and Patient Decision-Making (N=268)

Variables	Categories	f	%
Corporate Identity	Good	248	92.5
	Less good	20	7.5
Physical Environment	Good	230	85.8
	Less good	38	14.2
Contact Personnel	Good	231	86.2
	Less good	37	13.8
Service Offering	Good	135	50.4
	Less good	133	49.6
Corporate Individuality	Good	186	69.4
	Less good	82	30.6
Patient Decision-Making	Good	255	95.1
	Less good	13	4.9

Source: (Author Primary Data, 2022)

using questionnaires from 268 respondents. Table 1 presents the sociodemographic characteristics of the study participants.

The majority of respondents (55.2%) were adults aged 25.1-45 years, and 53.7% were female. Regarding education level, 39.2% had completed secondary education, while 34.3% had higher education. Most respondents (39.2%) worked as private employees, and 42.5% had a monthly income of IDR 2,000,000-3,000,000. Notably, 88.8% of respondents chose to utilize inpatient services at Nahdlatul Ulama Hospital Tuban based on their own decision.

The normality test using Kolmogorov-Smirnov yielded a significance value of 0.000 (<0.05). So the data were not normally distributed. Therefore, the median value was used as a measure of central tendency to categorize respondents' answers. Table 2 presents the univariate analysis of the five brand image dimensions and patient decision-making.

The majority of respondents perceived the hospital's brand image dimensions positively. Corporate identity was rated as good by 92.5% of respondents, physical environment by 85.8%, and contact personnel by 86.2%. Service offering had the lowest positive perception, with 50.4% rating it as good, while corporate individuality was perceived as good by 69.4% of respondents. Regarding the decision to utilize inpatient services, 95.1% of respondents gave a positive decision-making. The bivariate analysis using Spearman's rank correlation test showed significant relationships between all brand image dimensions and patient decision-making in utilizing inpatient healthcare services (Table 3).

TABLE 3. Bivariate Analysis of Brand Image Dimensions and Patient Decision-Making

Brand Image Dimensions	**Patient Decision-Making**				**Total**		**Correlation Coefficient (rho)**	**p-value**
	Good		**Less good**					
	n	**%**	**n**	**%**	**n**	**%**		
Corporate Identity								
Good	242	90.3	6	2.2	248	92.5	0.399	0.000
Less good	13	4.9	7	2.6	20	7.5		
Physical Environment								
Good	228	85.1	2	0.7	230	85.8	0.456	0.000
Less good	27	10.1	11	4.1	38	14.2		
Contact Personnel								
Good	225	84.0	6	2.2	231	86.2	0.262	0.000
Less good	30	11.2	7	2.6	37	13.8		
Service Offering								
Good	134	50.0	1	0.4	135	50.4	0.193	0.002
Less good	121	45.1	12	4.5	133	49.6		
Corporate Individuality								
Good	181	67.5	5	1.9	186	69.4	0.152	0.013
Less good	74	27.6	8	3.0	82	30.6		

Source: (Author Primary Data, 2022)

TABLE 4. Multiple Linear Regression Analysis of Brand Image Dimensions and Patient Decision-Making

Models	Sum of Squares	df	Mean Square	F	Sig.
Regression	815.027	5	163.005	42.990	0.000
Residual	993.421	262	3.792		
Total	1808.448	267			

Source: (Author Primary Data, 2022)

TABLE 5. Partial Effects of Brand Image Dimensions on Patient Decision-Making

Brand Image Dimensions	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	5.260	1.462		3.599	0.000
Corporate Identity (X_1)	0.072	0.057	0.071	1.257	0.210
Physical Environment (X_2)	0.138	0.072	0.129	1.907	0.058
Contact Personnel (X_3)	0.186	0.082	0.184	2.272	0.024*
Service Offering (X_4)	0.199	0.046	0.318	4.304	0.000*
Corporate Individuality (X_5)	0.117	0.053	0.115	2.179	0.030*

*Significant at $p<0.05$ Source: (Author Primary Data, 2022)

The strongest correlation was observed with physical environment (rho=0.456, $p<0.001$), followed by corporate identity (rho=0.399, $p<0.001$), both showing moderate correlations. Contact personnel demonstrated a weak correlation (rho=0.262, $p<0.001$), while service offering (rho=0.193, $p=0.002$) and corporate individuality (rho=0.152, $p=0.013$) showed very weak correlations with patient decision-making.

Multiple linear regression analysis was used to determine the simultaneous influence of the five brand image dimensions on patient decision-making (Table 4).

The F-test showed a significant model ($F=42.990$, $p<0.001$), indicating that all five brand image dimensions collectively influenced patient decision-making. The coefficient of determination (R^2) was 0.451; thus 45.1% of the variation in patient decision-making could be explained by the five brand image dimensions, while the remaining 54.9% was influenced by other factors not examined in this study.

The partial t-test results revealed that only three dimensions significantly influenced patient decision-making: contact personnel ($t=2.272$, $p=0.024$), service offering ($t=4.304$, $p<0.001$), and corporate individuality ($t=2.179$, $p=0.030$). Service offering had the strongest influence ($\beta=0.318$), followed by contact personnel ($\beta=0.184$) and corporate individuality ($\beta=0.115$). Corporate identity and physical environment did not show significant partial effects on patient decision-making. The role of brand image in influencing patient decision-making in inpatient healthcare utilization is a multifaceted topic that encompasses various elements such as reputation, service quality, and patient satisfaction. Recent studies have highlighted the significant impact of a hospital's brand image on patient choices, suggesting that a strong brand can differentiate a hospital in a competitive market and influence patient perceptions and decisions.

This study examined the influence of brand image dimensions on patient decision-making in utilizing inpatient healthcare services at RSNU Tuban. Our findings revealed that brand image, comprising corporate identity, contact personnel, service offering, and corporate individuality, significantly influenced patient decisions to utilize inpatient services ($F=42.990$, $p<0.001$). Specifically, three dimensions—contact personnel ($t=2.272$, $p<0.05$), service offering ($t=4.304$, $p<0.001$), and corporate individuality ($t=2.179$, $p<0.05$)—demonstrated significant individual effects on patient decision-making, while physical environment did not show a significant independent influence ($p=0.058$). Before examining individual dimensions, it's vital to recognize the broader influence of brand image

on healthcare decision-making. A positive brand image is closely related to perceived service quality, which affects patient satisfaction and loyalty. As Wu (2011) demonstrated, hospitals with a strong brand image are often perceived as providing better quality care, increasing the likelihood of patients choosing the same hospital for future needs. Hospital reputation, a component of brand image, can lead patients to travel longer distances to receive care from hospitals with better reputations, indicating that trust in the hospital's brand can outweigh logistical considerations (Pilny & Mennicken, 2015). Additionally, brand equity, which includes factors such as brand loyalty and perceived quality, represents a significant determinant of patient choice, with hospitals investing in strong brand equity, enhancing patient satisfaction and loyalty (Górska-Warsewicz, 2022).

Corporate identity showed a significant bivariate relationship with patient decision-making ($p<0.001$). It aligns with Rusmin *et al*. (2017) research finding notable associations between corporate identity and inpatient service utilization in private hospitals in Makassar. The logo's green color scheme and design elements resembling the NU (Nahdlatul Ulama) emblem created strong recognition among the predominantly Muslim and Nahdliyin population in Tuban. It illustrates Kurtz & Clow's (1998) in Kurtz & Clow (1998), theory that positive corporate imagery helps retain existing customers and attract new ones. The Islamic identity portrayed through the hospital's branding elements appeared to resonate strongly with the local demographic characteristics. Effective marketing and communication strategies emerged as implicit factors throughout our findings. While not measured as a separate dimension, the mechanisms through which RSNU Tuban communicated its values, services, and identity clearly influenced patient perceptions. It aligns with research by Maulana & Ayuningtyas (2023), who emphasized that effective marketing communication strategies are essential for establishing a strong brand image. Hospitals that successfully communicate their brand values and service quality can create positive perceptions among potential patients, influencing their healthcare provider choices.

The hospital's digital innovations, particularly the Go RSNU application and online services, represent efforts toward differentiation and innovativeness. Gurtner *et al*. (2018) and Dewi & Mahyuni (2024) noted that hospitals emphasizing innovativeness and cutting-edge capabilities enhance their brand image, positioning themselves as healthcare leaders. Although our study did not specifically measure innovativeness as a factor, the positive response to digital services suggests its contribution to the overall brand perception. Contact personnel demonstrated both a significant association ($p<0.001$) and influence ($t=2.272$, $p<0.05$) on patient decision-making. This aligns with studies by Andriani *et al*. (2021) and Rusmin *et al*. (2017) indicating significant relationships between contact personnel and inpatient service utilization. Most respondents (84%) positively evaluated staff appearance, clear information delivery, and professional competence. However, some respondents (22.4%) expressed concerns about inconsistent physician visiting schedules and unclear medication and dietary information from paramedical staff. Following Nguyen & Leblanc (2001) framework, evaluating contact personnel through appearance, competence, and professionalism, the findings suggest that positive patient-staff interactions significantly influence healthcare facility selection.

Service offering emerged as the most influential factor on patient decision-making ($t=4.304$, $p<0.001$). Half of respondents (50%) rated healthcare services positively, citing physician availability and responsiveness, streamlined administration, prompt pharmacy service, ease of communication with healthcare providers, and non-discriminatory treatment regardless of health insurance status. Conversely, 45.2% expressed dissatisfaction with inconsistent physician rounds. These findings align with Aprianti (2019) and Novita *et al*. (2023), who found significant relationships between service speed and intention to reuse inpatient services. RSNU Tuban's digital service innovations—including online registration through the Go RSNU application, free in-city medication delivery, gender-specific "syar'i" delivery services, and

emergency ambulance services—appeared to enhance the service offering dimension of its brand image. The strong influence of service offering aligns with research on diverse patient expectations. Stevany *et al*. (2024) noted that patient expectations vary widely, and hospitals must consider these differences when building their brand image. Factors such as tangibility, empathy, and responsiveness are crucial in shaping patient expectations and should be integrated into brand positioning. RSNU Tuban's focus on diverse service offerings appears to address this range of expectations effectively.

Corporate individuality showed a significant association ($p=0.013$) and influence ($t=2.179$, $p<0.05$) on patient decision-making. Most respondents (67.5%) positively evaluated the hospital's Islamic values, including gender-specific service options, spiritual guidance aligned with patient beliefs, and education about worship during illness. However, 27.6% felt the Islamic elements (Quranic recitations, religious posters, qibla directions) were insufficiently prominent. These findings parallel Rahayu *et al*. (2021) research showing significant relationships between corporate individuality and inpatient service utilization at Jember Clinic Hospital. RSNU Tuban's core value of "*Peduli*" (Care)—based on Islamic teachings emphasizing human service and interpreted as Professional, Empathetic, Disciplined, User-oriented, Loyal, and Innovative—appeared to resonate with the local Muslim-majority population.

This study has several limitations. First, the cross-sectional design limits causal inference between brand image dimensions and patient decision-making. Second, the study was conducted at a single Islamic hospital with distinctive demographic characteristics, potentially limiting generalizability to hospitals with different religious affiliations or in more diverse communities. Third, while we found that the physical environment was not independently significant in multivariate analysis despite showing a bivariate association, further investigation of potential confounding or mediating factors might reveal more complex relationships. Additionally, we did not directly measure the alignment between objective quality indicators and perceived brand image, which Ziemba *et al*. (2019) identified as a potential concern. Patient decisions based on perceived rather than actual quality could affect health outcomes, representing an important area for future research. Finally, while we examined five dimensions of brand image, other potential factors such as innovativeness and technological advancement were not explicitly measured, though they emerged implicitly in respondent feedback.

Our findings suggest several practical implications for hospital management. First, healthcare facilities should invest in staff training to enhance patient-provider interactions, as contact personnel significantly influence patient decisions. Second, service innovations like digital appointment systems, home medication delivery, and gender-specific care options appear to positively impact patient decision-making and could be considered by other facilities. Third, aligning corporate values with local population characteristics (as demonstrated by RSNU Tuban's Islamic identity in a predominantly Muslim area) may enhance brand image and patient attraction. Fourth, while physical environment did not independently influence patient decisions in this study, the 10.1% of respondents noting facility discrepancies and maintenance issues suggest that accurate representation of facilities and consistent upkeep remain important. Furthermore, hospitals should develop comprehensive marketing communication strategies that effectively convey their brand values and service quality. As Maulana & Ayuningtyas (2023) emphasized, successful communication can positively influence potential patients' perceptions and choices. Hospitals should also ensure alignment between their brand reputation and actual service quality, addressing the concern raised by Ziemba *et al*. (2019) regarding potential misalignment. By investing in brand equity while maintaining service quality, hospitals can enhance patient satisfaction and loyalty, creating a more stable patient base (Górska-Warsewicz, 2022).

Conclusion

Brand image significantly influences

patient decision-making in utilizing inpatient healthcare services. Contact personnel, service offering, and corporate individuality emerged as the most influential dimensions at RSNU Tuban, with service offering demonstrating the strongest effect. These findings highlight the importance of healthcare facilities developing comprehensive brand management strategies that emphasize service quality, staff interactions with patients, and corporate values aligned with target populations. While physical infrastructure matters, the human elements of healthcare delivery appear more decisive in patient decision-making. Our findings align with broader research demonstrating that brand image affects perceived service quality, trust, and patient satisfaction. Hospitals must recognize that patients may be willing to travel longer distances or overlook minor inconveniences for facilities with stronger reputations, suggesting that investment in brand development has tangible returns in patient attraction and retention.

However, it is essential for hospitals to ensure that their brand image aligns with actual service quality and patient expectations. This alignment can help build trust and loyalty among patients, ultimately leading to better health outcomes and a stronger competitive position in the healthcare market. Hospitals must be cautious of over-relying on brand image without substantiating it with objective quality measures, as this could lead to patient dissatisfaction and potential reputational damage. Future research should examine these relationships in diverse healthcare settings, explore potential mediating factors between brand image dimensions and patient decisions, and investigate the alignment between perceived brand quality and objective healthcare outcomes.

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KEMAS 21 (2) (2025) 402-410

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Preoperative Anxiety Levels and the Incidence of Postoperative Nausea and Vomiting in Patients Undergoing General Anesthesia

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Article Info

Article History:
Submitted: June 2025
Accepted: September 2025
Published: October 2025

Keywords:
preoperative anxiety; postoperative nausea and vomiting (PONV); general anesthesia

DOI
https://doi.org/10.15294/kemas.v21i2.27115

Abstract

Postoperative nausea and vomiting (PONV) are common complications after general anesthesia, negatively impacting patient comfort, recovery, and hospital stay. While many factors contribute to PONV, psychological aspects such as preoperative anxiety are often underestimated despite their influence on postoperative outcomes. This study aimed to analyze the relationship between preoperative anxiety levels and the incidence of PONV in patients undergoing surgery under general anesthesia. Using a cross-sectional design, 45 elective surgical patients were assessed for anxiety using the Hamilton Anxiety Rating Scale (HARS), and PONV incidence was recorded within 24 hours post-surgery. Chi-square analysis revealed a significant association between anxiety levels and PONV occurrence ($p = 0.002$). Among patients with moderate to severe anxiety, 73.3% experienced PONV, compared to only 26.7% among those with mild anxiety. These findings indicate that higher preoperative anxiety increases the risk of PONV. Therefore, integrating psychological assessment and anxiety management into perioperative care is crucial to reducing postoperative complications and improving anesthetic outcomes through a more holistic patient care approach.

Introduction

General anesthesia is a pharmacological intervention aimed at inducing a controlled, reversible state of unconsciousness that prevents the perception of pain, ensures loss of consciousness, and produces perioperative amnesia, thereby eliminating any recollection of the surgical procedure (Pavel *et al*., 2020). This physiological state is achieved through modulation of the central nervous system by anesthetic agents, which produce sedation, analgesia, and immobilization, ultimately creating an optimal surgical environment for both the patient and the operative team (Ring *et al*.,2021).Generalanesthesiacanbeadministered through three primary pharmacodynamic approaches: inhalational, intravenous, and balanced techniques. Inhalational anesthesia involves the administration of volatile anesthetic agents—such as isoflurane, sevoflurane, enflurane, desflurane, and nitrous oxide—delivered via mechanical ventilation into the respiratory tract and absorbed into the pulmonary circulation to exert their effects on the brain (Niu *et al*., 2021). Conversely, intravenous techniques employ parenteral agents such as propofol, ketamine, midazolam, thiopental, and opioids, which are injected directly into the bloodstream, offering rapid onset and precise titration of anesthetic depth (Kim & Fechner, 2022). Balanced anesthesia is designed to integrate the advantages of both inhalational and intravenous approaches. This strategy synergistically combines agents from both routes and is frequently complemented by regional nerve blocks to fulfill the principles of the Anesthesia Triad—hypnosis, analgesia, and muscle relaxation—in a comprehensive and harmonized manner. The result is a more stable anesthetic control with minimized systemic

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pISSN 1858-1196
eISSN 2355-3596

side effects(Pavel *et al*., 2020).

In the preoperative phase, a patient's psychological status—particularly anxiety—represents a critical determinant that must not be overlooked. Preinduction anxiety has been shown to trigger dysregulation of neuroendocrine and autonomic responses, contributing to early hemodynamic instability and heightened sensitivity to postoperative stimuli (Wang *et al*., 2022). One of the most commonly observed clinical consequences is Postoperative Nausea and Vomiting (PONV), a distressing complication characterized by nausea and vomiting following emergence from anesthesia. PONV not only diminishes patient comfort but also extends hospitalization duration and increases the risk of secondary complications. Consequently, the interplay between preoperative psychological conditions and postoperative physiological manifestations has become a central concern in optimizing modern anesthetic management. Postoperative Nausea and Vomiting (PONV) is among the most frequently reported postoperative complications, particularly among patients undergoing surgical procedures under general anesthesia. Although not directly life-threatening, PONV exerts a substantial impact on clinical recovery, prolongs hospital stay, and elevates the demand for adjunctive pharmacological therapies. These consequences collectively contribute to increased healthcare costs and impose additional burdens on medical personnel (Gan *et al*., 2020). Global data reveal that over 30 million patients annually experience PONV symptoms, with prevalence rates ranging from 25% to 30%, depending on the patient population, type of surgery, and anesthetic techniques employed (Gan *et al*., 2020).

Numerous international studies have documented the high prevalence of PONV, including findings from India involving patients classified as ASA physical status I and II undergoing elective surgery under general anesthesia, as well as European reports indicating incidence rates as high as 44–56% in several developed nations (Kovac, 2021). Domestic studies likewise reveal that this complication remains a critical concern across major healthcare institutions, with incidence rates varying significantly between facilities. These findings underscore the necessity of adopting a more integrative and predictive approach to understanding the predisposing factors that contribute to the onset of PONV. Among the emerging areas of interest in the past decade is the psychological dimension of preoperative patients—particularly anxiety levels—which may influence neurophysiological responses to anesthesia and the metabolism of anesthetic agents. Preoperative anxiety has been shown to modulate sympathetic nervous system activation, resulting in hemodynamic instability and increased visceral sensitivity to postoperative emetogenic stimuli (Jin *et al*., 2020). Although several studies have generally addressed this issue, there remains a paucity of research that quantitatively and contextually examines the association between preinduction psychological profiles and PONV incidence, especially within local patient populations.

Therefore, this study was conducted at a tertiary-level hospital in North Sumatra to examine the extent to which preoperative anxiety levels are associated with the incidence of PONV in patients undergoing general anesthesia procedures. By integrating psychological and clinical approaches, this research aims to provide a more holistic understanding of the determinants of PONV, as well as to encourage the implementation of more comprehensive preoperative evaluations in anesthetic practice. The findings are also expected to reinforce the role of healthcare professionals in anticipating postoperative complication risks through more preventive and individualized strategies.

Method

This study used a quantitative approach with an analytic correlational design to examine the relationship between psychological indicators and postoperative clinical manifestations. A cross-sectional methodology was employed to capture a snapshot of the association between independent and dependent variables at a specific point in time (Ida *et* al., 2020). This design enables the researcher to evaluate the psychological condition before the medical procedure alongside the physiological response following general anesthesia within a

single observational phase, without intervening in the clinical process. The participants in this study comprised adult patients undergoing elective surgery under general anesthesia at a secondary referral hospital in Northern Sumatra. The subject selection process adhered to stringent criteria to ensure homogeneity of sample characteristics and minimize data distortion caused by confounding variables. The inclusion criteria encompassed patients who consented to participate, classified as ASA physical status I–II, undergoing anesthesia lasting 30–60 minutes, receiving induction with propofol and maintenance with sevoflurane inhalation, and administered prophylactic antiemetics. Exclusion criteria included neurological conditions such as stroke, impaired consciousness, electrolyte and acid-base imbalances, as well as patients undergoing surgeries involving the abdominal region and ENT organs. Sampling was conducted consecutively, whereby all patients meeting the criteria were enrolled until the required sample size was achieved. This approach provided control over selection bias and enhanced representativeness within the context of actual clinical practice. Data collection was conducted through a structured approach by two primary instruments.

Preoperative anxiety levels were measured using the Hamilton Anxiety Rating Scale (HARS), a widely validated clinical research tool (Husna *et al*., 2022). This scale comprises 14 anxiety symptom indicators, each rated on an ordinal scale ranging from 0 to 4, reflecting symptom severity from mild to extremely severe. This method facilitates the objective quantification of individual anxiety levels within the preoperative context. Concurrently, the incidence of postoperative nausea and vomiting (PONV) was identified through direct clinical observation following general anesthesia. Observations focused on the critical postoperative period, documenting symptom onset, frequency, and severity according to a structured classification system. PONV events were categorized using a numerical scale: a score of 0 denoting absence of symptoms, 1 indicating mild nausea complaints, 2 representing retching without vomiting, and 3 reflecting severe nausea accompanied by vomiting two or more times or persisting for over 30 minutes. All documentation was conducted uniformly, utilizing standardized observation sheets and manual timing devices to ensure data accuracy and reproducibility.

Data processing was conducted systematically through several stages, beginning with the editing of questionnaire responses to ensure the integrity and completeness of data, followed by numerical coding to maintain participant anonymity. The data were subsequently entered into tabulated formats using statistical software and rechecked to identify any input errors that could potentially compromise the accuracy of the analysis results. The analysis proceeded in two phases: univariate analysis to describe the distribution of respondent characteristics and key variables, and bivariate analysis employing Spearman's Rho test to evaluate the strength of the association between preoperative anxiety levels and the incidence of PONV. A p-value threshold of 0.05 was set to determine statistical significance. The interpretation of the correlation coefficient adhered to a scale ranging from 0.000 to 1.000, from very weak to very strong relationships, thereby facilitating clinically relevant conclusions.

Result And Discussion

Based on Table 1, out of a total of 50 participants, the majority (86%) were aged between 41 and 60 years. This finding indicates that most patients undergoing surgical procedures with general anesthesia belong to the middle-aged to pre-elderly demographic. Physiologically, this age group is more susceptible to autonomic dysregulation and heightened emotional responses to invasive interventions. With advancing age, concerns regarding surgical outcomes, dependence on family support, and past healthcare experiences contribute to elevated anxiety levels and a predisposition to anesthesia-related side effects, such as postoperative nausea and vomiting (PONV). The proportion of male and female respondents in this study was nearly equal, with a slight predominance of females (52%). From both psychological and biological perspectives, females are often reported to have different pain and anxiety thresholds compared

TABLE 1. Respondent Characteristic

Characteristics	Values	Frequency (n)	Percentage (%)
Age Scale	20-40 years	7	14,0
	41-60 years	43	86,0
	Total	50	100,0
Gender	Male	24	48,0
	Female	26	52,0
	Total	50	100,0
Last Education	Elementary/junior high school	7	14,0
	Senior high school	37	74,0
	Diploma/bachelor	6	12,0
	Total	50	100,0
Employment Status	Employment	24	48,0
	Unemployment	26	52,0
	Total	50	100,0
Anxiety Category	None	15	30,0
	Mild	7	14,0
	Moderate	10	20,0
	Severe	16	32,0
	Panic	2	4,0
	Total	50	100,0
PONV Category	No nausea	0	0,0
	Nausea only	15	30,0
	Retching and vomiting	30	60,0
	Nausea >30 minutes and >twice	5	10,0
	Total	50	100,0

Source: primary data, research result (2025)

to males, which may contribute to variations in susceptibility to postoperative symptoms, including postoperative nausea and vomiting (PONV).

The majority of participants (74%) possessed a high school level education background. This demographic reflects a moderate level of health literacy, which likely influences patients' comprehension of medical information, psychological preparedness before surgery, and stress management capabilities. A lower level of higher education may diminish understanding of surgical procedures and anesthesia-related risks, thereby elevating preoperative anxiety, which in turn potentially increases the incidence of postoperative nausea and vomiting (PONV). The majority of respondents (52%) were economically inactive, reflecting a potential increase in psychosocial burden. Economic inactivity is often correlated with lower perceived control over various aspects of life, including health. This condition may trigger excessive anxiety before medical procedures and exacerbate the body's stress response to stimuli such as anesthesia, thereby contributing to the manifestation of gastrointestinal symptoms like postoperative nausea and vomiting (PONV).

More than half of the respondents (66%) exhibited anxiety levels ranging from moderate to panic, with the highest proportion falling within the severe anxiety category at 32%. This finding indicates a significant prevalence of anxiety as a psychological response to uncertainty, fear of the anesthetic procedure, and concerns regarding surgical outcomes. Preoperative anxiety is known to activate the sympathetic nervous system and induce hormonal changes that disrupt autonomic stability, potentially exacerbating the patient's physiological condition during and after anesthesia. All respondents (100%)

TABLE 2. Correlation between Preoperative Anxiety and PONV

Anxiety level	Nausea	Retching	Nausea >30m & vomit >x	Total	Correlation
None	9	6	0	15	
Mild	1	5	1	7	
Moderate	4	5	1	10	
Severe	1	13	2	16	
Panic	0	1	1	2	p=0,001; r=0,463

Source: SPSS output, processed by Researcher (2025)

experienced symptoms of PONV at varying degrees of severity, with 60% suffering from active retching and vomiting. This finding reinforces the hypothesis that PONV is a common and significant complication following general anesthesia. The absence of patients without symptoms indicates a very high risk of PONV within this population, highlighting the necessity for an integrated preventive approach that includes preoperative psychological management. To examine the relationship between preoperative anxiety and PONV, a Spearman Rank correlation test was conducted. The results are presented in Table 2.

The analysis results revealed a significant positive correlation between preoperative anxiety levels and the severity of PONV ($p = 0.001$), with a correlation coefficient of 0.463. It indicates that higher levels of anxiety before anesthesia are associated with an increased likelihood of experiencing more severe PONV symptoms. This phenomenon can be explained by the activation of the hypothalamic–pituitary–adrenal (HPA) axis and neurochemical disturbances affecting the vomiting center located in the area postrema of the medulla oblongata. This study revealed a significant relationship between preoperative anxiety and the incidence of postoperative nausea and vomiting (PONV) after general anesthesia ($p = 0.001$; $r = 0.463$). These findings strengthen the underlying hypothesis that patients' preoperative emotional state, particularly anxiety, serves as a critical predictor of postoperative adverse events, particularly PONV. These results are in line with research by (Yokoyama *et al*., 2024), which showed that patients with high levels of anxiety were significantly more likely to experience PONV than patients with low levels of anxiety.

A European study (2024) reported that an increase in the STAI score was directly related to the frequency of PONV in laparoscopic surgery patients. A study conducted in Iran found correlation coefficients ranging from 0.54 to 0.60 between preoperative anxiety and the occurrence of PONV, highlighting that anxiety not only serves as a related factor but also as an active contributor to the increased physiological response to anesthesia (Mohebi *et al*., 2021). All these findings suggest that preoperative anxiety is not simply a companion variable, but rather a determinant that amplifies physiological sensitivity to the effects of anesthesia. These results are also in line with psychoneuroimmunology theory, which explains how emotional disorders can affect the autonomic nervous and neuroendocrine systems, which in turn affect physiological functions, including the digestive system. Neurobiologically, preoperative anxiety triggers activation of the limbic system—especially the amygdala and hippocampus—areas involved in threat perception and stress responses. This activation initiates the release of adrenocorticotropic hormone (ACTH), causing an increase in plasma levels of cortisol and catecholamines. Increased catecholamines stimulate the vomiting center in the medulla oblongata via afferent pathways from the vagus nerve and vestibular system, while also causing an imbalance in neurotransmitters such as serotonin and dopamine, which are known as key mediators in the pathophysiology of PONV (Hanalis-Miller *et al*., 2022; Stoops & Kovac, 2020). Literature from Denholm & Gallagher (2021) also describes the involvement of substances such as acetylcholine and substance P in this pathway, strengthening the link between psychological stress and somatic manifestations in the form of nausea and vomiting. Other research conducted by Yokoyama *et al*., and

Mou *et al*., (2024; 2024) also agrees with the results of this study, showing that patients with high levels of anxiety are significantly more likely to experience PONV than patients with low levels of anxiety.

The findings of this study showed that most patients who experienced moderate to high levels of anxiety experienced more severe postoperative nausea and vomiting (PONV). It suggests that anxiety is not just an accompanying variable but is a functional determinant that worsens the patient's physiological sensitivity to the effects of anesthesia. Even in the absence of classic risk factors such as female gender, previous history of PONV, or opioid use, anxiety remains a significant contributor to the increased incidence of nausea and vomiting. It suggests that subjective perceptions of medical threats, such as concerns about loss of control while unconscious or complications from anesthesia, have a real biological impact on the digestive system and vomiting control centers. The interaction between these factors amplifies psychological stress, which ultimately manifests as somatic responses such as gastrointestinal symptoms. In this context, the theory of psychoneuroimmunology provides a comprehensive scientific framework, explaining how emotional disorders directly impact the function of the autonomic nervous and neuroendocrine systems. Interestingly, these reactions are often disproportionate to the intensity of the anesthetic stimulus itself, thus highlighting the fact that the patient's subjective perception of a medical threat has a real biological effect. Although classic risk factors such as gender, history of PONV, and opioid use were not analyzed explicitly in this study, global literature suggests that women are more susceptible to PONV due to hormonal fluctuations (estrogen & progesterone) that increase the excitability of the vomiting center (Liao *et al*., 2024; Wu *et al*., 2022). Therefore, preventive strategies for female patients with high anxiety, such as low-dose serotonin antagonist premedication, become highly relevant.

In terms of demographics, the 41-60 year age group dominates the study population. This age range is typically characterized by a peak in social and economic responsibilities, which, from a psychodynamic perspective, may increase vulnerability to anxiety. Liu *et al*. (2023) showed that middle-aged patients often show higher levels of anxiety than elderly patients due to role conflicts and concerns regarding family welfare after surgery. Therefore, anesthetic approaches in this age group should take psychological considerations more strictly into account. Regarding gender, although this study did not explicitly analyze differences in PONV incidence based on gender, the existing literature consistently reports that women have a greater risk of experiencing PONV. It is related to hormonal fluctuations—especially estrogen and progesterone—which can affect sensitivity to inhalation anesthetics and opioids, as well as increase stimulation of the vomiting center in the brain. The Cambridge Core meta-analysis (2025) also found that preoperative anxiety occurs in 60–80% of patients and is associated with increased need for anesthesia, delirium, and duration of recovery. Although the direct effect on PONV is not always consistent, a strong biological suggestion and clinical association are present. Therefore, gender-specific interventions—such as premedication with low-dose serotonin antagonists for female patients with high anxiety—may serve as an effective PONV prevention strategy.

Educational aspects have also been shown to contribute significantly to patients' perceptions and responses to medical procedures. The formal education of the respondents, most of whom only completed secondary school, was associated with low health literacy. Limited understanding of anesthesia often creates an information vacuum filled with misunderstandings or irrational fears. The absence of adequate preoperative education exacerbates anxiety and contributes to increasing the likelihood of maladaptive psychophysiological reactions, such as PONV. Therefore, structured preoperative education should be considered an integral component of perioperative management, especially for patients with low health literacy (Darville-Beneby *et al*., 2023). This study also underscores the importance of integrating anxiety assessment tools—such as the Amsterdam Preoperative Anxiety and Information Scale (APAIS) or the Spielberger State-Trait Anxiety

Inventory (STAI)—into standard preoperative protocols. Early detection of patients with high levels of anxiety allows for multidisciplinary involvement, including psychological counseling or psychiatric support, before surgery. This approach has the potential not only to reduce the incidence of PONV but also to speed postoperative recovery and shorten hospital stays.

In terms of intervention, non-pharmacological approaches such as virtual reality (VR) and psychoeducation have shown effectiveness in reducing preoperative anxiety and the incidence of PONV (Chiu *et al*., 2023; Kusumadewi *et al*., 2024; Li *et al*., 2025; Ugras *et al*., 2023). In addition, a study in egg retrieval patients found that preoperative use of ondansetron reduced PONV in the group with high anxiety (SAS 50–60), but not significantly in the group without anxiety (Mou *et al*., 2024). It suggests that special attention to the patient's emotional state before surgery may increase the effectiveness of PONV prevention strategies (Wijaya & Megawati, 2023). A meta-analysis with 1,389 patients showed that preoperative anxiety was indeed associated with PONV, but adding anxiety scores to a prediction model that already contained other risk factors did not improve accuracy (AUC remained ≈ 0.72). However, a recent pilot study using the Hospital Anxiety and Depression Scale (HADS) in thoracic surgery patients reported that adding the HADS score to the prediction model significantly increased the AUC (p=0.021), demonstrating the potential clinical value of anxiety assessment (Yokoyama *et al*., 2024).

Overall, strong empirical evidence from a variety of populations and settings supports that preoperative anxiety contributes to increased PONV incidence via neuroendocrine and autonomic nervous mechanisms. As a clinical implication, it is crucial to incorporate anxiety assessment tools, such as STAI, APAIS, or HADS into the preoperative protocol (Suryani *et al*., 2021). This screening allows for targeted psychological and pharmacological-based interventions, as well as the use of supportive non-pharmacological strategies, which together can reduce the incidence of PONV, speed recovery, and reduce treatment costs.

Conclusion

Based on the findings of this study, it can be concluded that there is a significant relationship between the level of preoperative anxiety and the incidence of postoperative nausea and vomiting (PONV) in patients undergoing surgery under general anesthesia. The results indicate that higher levels of anxiety before surgery are associated with an increased likelihood of experiencing PONV, underscoring the critical role of psychological factors in shaping postoperative physiological responses. This mechanism is presumed to occur through the activation of the autonomic nervous system and heightened sensitivity of the vomiting center triggered by psychological stress. Accordingly, the management of preoperative anxiety should be considered an integral component of anesthetic protocols to reduce PONV incidence, enhance patient comfort, and expedite recovery. These findings reinforce the importance of a holistic, multidisciplinary approach in perioperative care and highlight the potential for structured psychological interventions as preventive strategies against anesthesia-related complications.

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KEMAS 21 (2) (2025) 411-422

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Pentahelix Collaboration in Achieving Disaster Preparedness through Resilient Villages: A Systematic Literature Review

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Article Info

Article History:
Submitted: July 2025
Accepted: September 2025
Published: October 2025

Keywords:
Collaboration; Disaster Preparadness; Disaster-Resilient Village; Penthahelix; Systematic Literature Review

DOI
https://doi.org/10.15294/kemas.v21i2.29453

Abstract

Pentahelix is one of the disaster preparedness approaches. This study aimed to provide an overview of the roles of each component in pentahelix collaboration occurring in several countries, thereby enhancing the effectiveness of disaster preparedness. Indonesia is the country with the second-highest disaster risk in the world, with a total of 3,472 disasters occurring in 2024.. Pentahelix collaboration has not been optimal, and disaster preparedness has not been achieved. This systematic literature review was conducted in accordance with PRISMA guidelines, compiling relevant studies from databases including PubMed, ScienceDirect, and Scopus. The literature search was carried out between April and June 2024 using specific keywords. The search yielded a total of 3.848 articles across the selected databases. Of these, 2.384 articles were obtained from Scopus, 1.277 from Science Direct, and 187 from PubMed. After the screening process, 13 relevant articles were identified for further review. Conclusion: the Government, private sector, community, academics, and media play crucial roles in disaster preparedness effectiveness. Overall, the success of disaster preparedness depends on strong cooperation and coordination among all stakeholders. Strong coordination and close collaboration among all stakeholders through Penthahelix collaboration are crucial to minimize the impact of disasters and accelerate the recovery of critical infrastructure.

Introduction

The 2022 World Risk Report (WRR) indicated that the Philippines, India, and Indonesia ranked among the top three countries with the highest disaster risk index (IFHV, 2022). As entities responsible for public safety, governments have undertaken disaster mitigation efforts (Huang *et al*., 2021; Yulianto *et al*., 2021). However, these efforts have not established a resilient preparedness system (Mas'Ula *et al*., 2019). In some regions of Indonesia, local governments and their apparatus lack preparedness when disasters strike (Andreastuti *et al*., 2019).

Aligned with the formula where hazard equals risk divided by capacity, reducing hazard necessitates increasing the capacity of actors or regions (Gerges *et al*., 2023). In other words, if more actors possess the capacity for disaster preparedness and response in an area, the region's hazard will be more negligible, or its disaster risk index will be lower (Hardy *et al*., 2020). Pentahelix is a development model of the Quadruple Helix. The number of stakeholders involved increases, and multisectoral mechanisms become more comprehensive. Comprehensive actions and role allocation make disaster management efforts more effective (Haifani *et al*., 2022). The pentahelix collaboration, comprising government, private sector, community, academia, and media, has a distinct role based on its potential (Guzmán-

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pISSN 1858-1196
eISSN 2355-3596

Cortés *et al*., 2022; Haksama *et al*., 2022). Each component of the pentahelix plays a role in every phase of a disaster: pre-disaster, disaster response, and post-disaster recovery. Within the disaster phase, preparedness focuses on the first quadrant, pre-disaster (Haifani & Paripurno, 2022). Disaster-aware components can increase the willingness and awareness to collaborate with various parties to anticipate potential regional disasters (Westcott *et al*., 2020; Yuningsih *et al*., 2017). Prior research has yet to comprehensively discuss all components of the pentahelix collaboration in disaster preparedness. Therefore, this systematic literature review aims to describe the roles of each element in the pentahelix collaboration occurring in several countries, thereby enhancing the effectiveness of disaster preparedness.

Methods

The systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, as described in the Cochrane Collaboration Handbook. Relevant studies were sourced from databases including PubMed, ScienceDirect, and Scopus through advanced search techniques by using Boolean operators (AND/OR). The keywords employed were refined using Medical Subject Headings (MeSH) to ensure comprehensive coverage of relevant literature (Figure 1). The literature search was carried out between April and June 2024.

The inclusion criteria for this study were: (1) the study population was disaster-resilient villages or areas with disaster preparedness schemes; (2) articles published within the past five years (2019–2024); (3) articles in English and full-text; (4) qualitative or mixed-methods studies; (5) original research publications. The exclusion criteria in this study were: (1) studies in areas without disaster preparedness; (2) articles published before 2019 were excluded from the review; (3) articles that were not in English, not open access, and only provided abstracts; (4) publications in the form of review articles, book chapters, or encyclopedia entries. The selection and screening of studies were carried out using Mendeley Desktop. Studies deemed irrelevant and duplicate records were excluded. The remaining articles were then evaluated according to predefined inclusion and exclusion criteria. Data extraction was conducted systematically, ideally involving more than one researcher to reduce potential bias. The extracted data included author names, study location, study objective, research design, pentahelix components, and key findings. Article quality was appraised using ten criteria derived from the Joanna Briggs Institute (JBI) and the Mixed Methods Appraisal Tool (MMAT). Based on the proportion of positive responses, the risk of bias was categorized as high (<30%), moderate (31%–70%), or low (>70%).

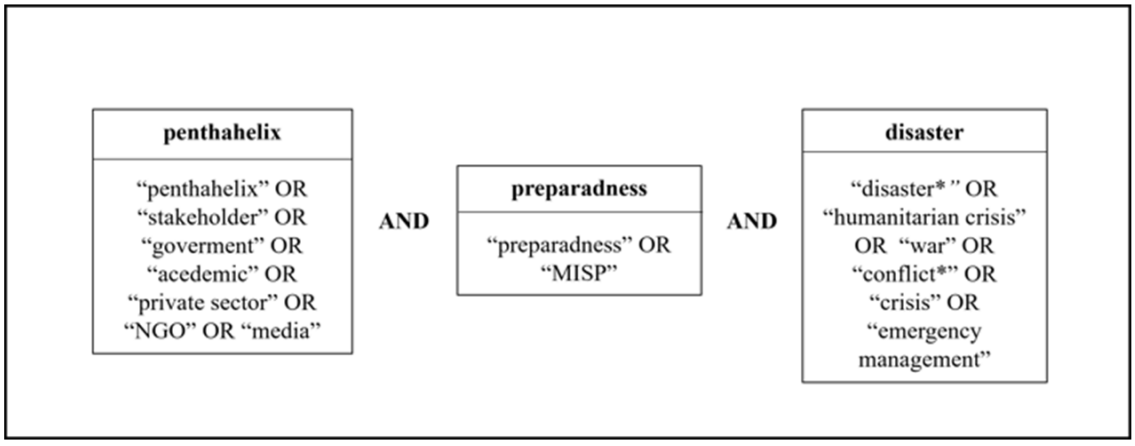

Figure 1. Keywords

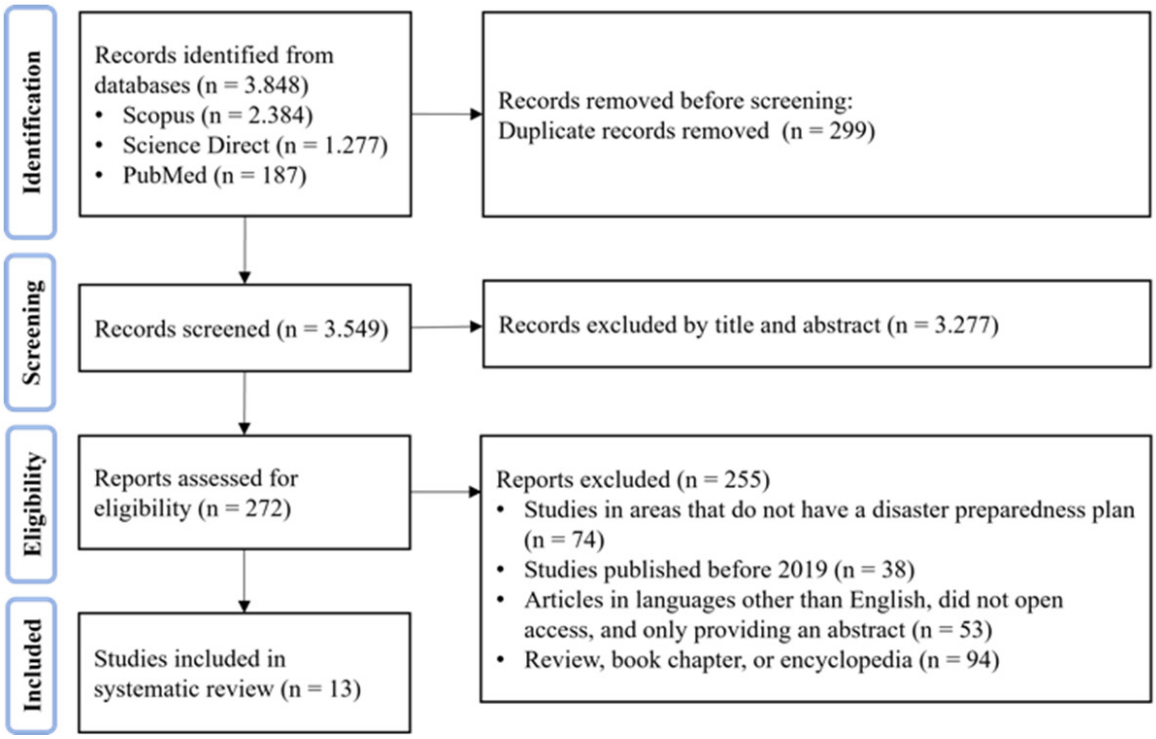

Figure 2. PRISMA Flow

Result and Discussion

The selection of studies adhered to the PRISMA guidelines, as depicted in Figure 2. From the results of the article search through databases using relevant keywords and considering the year of publication, 3,848 articles were found. In the final stage, 13 articles were selected for further analysis.

Of the 13 studies obtained, 2 were mixed-methods, while the remaining 11 were qualitative. The characteristics of the studies are classified in Table 1. Based on the assessment of article quality using the JBI Critical Appraisal Tools for qualitative studies and MMAT for mixed-methods studies, all 13 articles had a low bias, with "yes" answer obtained above 70% for all articles.

The pentahelix approach, as a collaborative or multi-stakeholder strategy, integrates various elements such as government, corporations, educational institutions, communities, and media to solve problems and develop programs by involving different sectors in role-sharing (Pasaribu *et al.*, 2023).

Table 1. Characteristics of the Studies

Author, year	Countries	Objectives	Methods, Design	Pentahelix Components	Findings
(Krongthaeo *et al.*, 2021)	Thailand	This study aimed to describe flood experiences, flood preparedness, and collaboration of care for dependent older adults and their family caregivers in Thai communities.	Qualitative study	Non-governmental Organizations (NGO)	This study emphasizes the importance of an inclusive community-based approach that considers the specific needs of dependent elderly individuals in flood preparedness planning and implementation.

Author, year	Countries	Objectives	Methods, Design	Pentahelix Components	Findings
(Vij *et al*., 2020)	Nepal	This article explains various disaster governance paradigms that have emerged and currently exist in Nepal.	Qualitative case study	Government, stakeholders, media	This study explains that the evolution of disaster governance in Nepal towards a more inclusive, decentralized, and technology-based approach has enhanced the country's capacity to respond to disasters more effectively and sustainably.
(A. Hermawan *et al*., 2024)	Indonesia	This study investigates community engagement in fostering disaster preparedness in the Kepuharjo and Umbulharjo, the most vulnerable villages of Merapi slopes in the Cangkringan District of Sleman Regency.	Qualitative field study	Non-governmental Organizations (NGO)	The finding implies the significance of encouraging structural and cognitive approaches in developing policies to strengthen community-based disaster resilience and, in the theoretical insights, broadening the social capital lens in social studies of disaster.
(Sandaran & Selvaraj, 2021)	Malaysia	This study aimed to understand how government communication shapes responses, actions, and community empowerment in flood preparedness.	Qualitative study	Government	Government agencies' communication style regarding flood preparedness can influence how they respond to floods and whether communities are empowered to take action themselves. The findings suggest a focus on traditional relief and rehabilitation, potentially neglecting the importance of community involvement.
(R. Jayasekara *et al*., 2022)	Sri Lanka	This study evaluated the network of stakeholders in the National Early Warning System of Sri Lanka during preparedness planning.	Qualitative study	Stakeholder, government, private sector	Risk governance, emergency response and preparedness measures, institutional collaboration, community engagement in disaster preparedness planning and response, and the well-being of vulnerable communities were significantly affected during the COVID-19 pandemic. To cope these challenges, improvements such as a sound legal basis, strong institutional coordination among stakeholders, emulation of a multi-sectoral approach including the health sector, empowering local authorities, and strengthening hazard forecasting and predictions are needed.

Author, year	Countries	Objectives	Methods, Design	Pentahelix Components	Findings
(Nick *et al*., 2023)	Western Germany	This study explored collaborative processes in the disaster response of critical water and health sectors following the 2021 floods in Western Germany.	Qualitative study	Stakeholder, Non-governmental Organization (NGO)	Organizational factors, including collaboration, coordination, communication, information management, and time management, were vital and interacted with physical, human, and social aspects and the overarching legal frameworks and policies within the disaster context. Lacking many enabling factors, the German flood response was insufficient, showing that critical infrastructures, interdependencies, and collaborative processes need a more substantial consideration in preparedness planning.
(Seddighi *et al*., 2023)	Iran	This study identified challenges of the existing disaster preparedness education programs for children in Iran.	Qualitative study	Academic, stakeholder, Non-governmental Organization (NGO)	The main challenges of disaster education programs in Iran are Communication (stakeholder communication, stakeholders' recognition, informing of stakeholders, and reliability), planning (sustainable planning, timetable, inclusivity, educational resources), coordination (inter-organizations, intra-organizations), and logistics (staff, trainers, equipment, budget).
(Graham *et al*., 2022)	Eastern Caribbean countries	This study aimed to identify and evaluate effective stakeholder relationship management strategies for improving situation awareness during volcanic emergencies in the Eastern Caribbean region.	Qualitative case study	Stakeholder	Strong relationships between volcano scientists and authorities, coupled with purpose-driven communication methods, can improve decision-making capacity among public officials, reducing public vulnerability.

Author, year	Countries	Objectives	Methods, Design	Pentahelix Components	Findings
(Beek *et al*., 2021)	Fiji and Tonga	This study aimed to identify the capacity development activities undertaken in the SPRINT program in Fiji and Tonga and how these enabled the sexual and reproductive health (SRH) response to Tropical Cyclones Winston and Gita.	Qualitative study	Non-governmental Organizations (NGO), stakeholder	This research has outlined the need for comprehensive activities at multiple levels within a country and across the Pacific region to build capacity for an SRH response in crises. The study highlights the importance of formal partnerships, regular communication, institutionalizing, accountability mechanisms, and training to ensure up-to-date coordination efforts in disaster readiness.
(Booth *et al*., 2020)	European countries	This study aimed to identify and evaluate solutions involving stakeholders in building interdisciplinary and international synergies between Climate Change Adaptation and Disaster Risk Reduction.	Quantitative and qualitative study (mixed-methods)	Stakeholder, private sector	The research results emphasize the importance of clear communication, maintaining political support, and involving the currently under-utilized private sector in positively establishing closer cooperation between Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR).
(Hasbi *et al*., 2023)	Indonesia	This study optimizes the implementation of the School Development Plan in flood disaster mitigation policies on a tropical rain forest at State Junior High School 5 Samarinda.	Qualitative study	Academic, stakeholder	The conceptualization of the School Development Plan in the flood disaster mitigation policy in a tropical rain forest at the State Junior High School 5 Samarinda, through environmental data analysis, stakeholder participation, and accommodating the concept of tropical schools, has been fully optimized. Implementing the School Development Plan in flood disaster mitigation policies in a tropical rain forest at State Junior High School 5 Samarinda through three basic mitigation programs and periodic evaluations has not been optimal.
(Khaledi *et al*., 2023)	Iran	This study aimed to investigate factors affecting the participation of NGOs in disaster management in Iran.	Qualitative study	Non-governmental Organization	Factors affecting the participation of NGOs in disaster management were classified into four main categories and 14 subcategories, including organizational and managerial, field and operational, social and cultural, and policymaking factors.

Author, year	Countries	Objectives	Methods, Design	Pentahelix Components	Findings
(Jardine *et al*., 2023)	United Kingdom	This study examines the extent to which meteorological variability, short-term response, and long-term policies contributed to the catastrophe of Storm Dennis and Ciara.	Quantitative and qualitative study (mixed-methods)	Media, government	The study underlines the importance of multidisciplinary research in understanding extreme weather events and exhibits the diverse factors that cause catastrophes.

Source: Primary Data, 2025

Roles of Stakeholders and Government in Disaster Preparedness

Each stakeholder has a unique and complementary role in detecting, disseminating information, and responding to multi-hazard threats amidst biological outbreaks (Graham *et al*., 2022; R. U. Jayasekara *et al*., 2023). Strong coordination and close cooperation among all stakeholders are vital to minimizing the impacts of disasters and accelerating the recovery of critical infrastructure (Ashraf *et al*., 2023; Nick *et al*., 2023). Research in the Philippines highlights the role of national institutions in providing technical support, funding, and resources to local governments. They also offer guidelines and frameworks for disaster preparedness and response (Dariagan *et al*., 2021; Kanteler & Bakouros, 2024). Local governments play a vital role in coordination; provincial disaster agencies (BPBD) can unite various sectors (Handayani *et al*., 2024). From the perspective of reproductive health during disasters, strengthening reproductive health communication in early marriage is a critical component of disaster preparedness, where the role of stakeholders—such as health educators, community leaders, and policy makers—is essential in ensuring that young couples are equipped with the knowledge and resources needed to manage reproductive health risks in emergency contexts (Najib *et al*., 2020; Nisa *et al*., 2025).

The government is crucial in driving coordination to strengthen connections among the pentahelix components. The government has supporting resources to accommodate meetings involving the other four elements of the pentahelix. The established coordination serves as a medium to map the potential of each component within the pentahelix as well as the roles that can be played to build preparedness in the region. Research in Nepal underscores the role of the government in strengthening policies, decentralizing authority, adopting technology, building capacity, and cooperation and coordination with various stakeholders as the key to enhancing the country's capacity to deal with disasters more effectively and sustainably (Márquez-Lameda, 2022; Vij *et al*., 2020). Government efforts not only improve the efficiency of disaster response but also strengthen the capacity of communities to withstand and recover from the impacts of disasters (Bera, 2023; Lalancette & Charles, 2022). The government's active role in all aspects of flood disaster preparedness demonstrates the importance of government leadership and support in reducing disaster risk and improving public safety and well-being (Sandaran & Selvaraj, 2021).

Role of the Private Sector in Disaster Preparedness

The private sector is often overlooked in efforts to integrate Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR). The private sector can help provide the resources, innovation, and technology needed to improve disaster preparedness and mitigation (Booth *et al*., 2020). Contributions by the private sector in biological outbreak situations include technology infrastructure, financial support, innovation, and the provision of health services. Financial investments from private companies

can help maintain and improve the capabilities of early warning systems (Gozzoli *et al*., 2024). In preparing logistics preparedness, including food and health, private sector support is needed. Disaster-affected communities will need personal hygiene kits (dignity kits) during emergencies. Logistics preparedness, with the support of the private sector, will be able to reduce the time required for distribution and expand the distribution coverage area during emergencies.

In Sri Lanka, the private sector contributes to disaster preparedness by supplying technological infrastructure, including Multi-Hazard Early Warning Systems (MHEWS), through telecommunications, data processing, and information dissemination systems to ensure timely alerts reach the public. Public–private collaboration plays a vital role in enabling the exchange of resources, expertise, and knowledge to strengthen disaster risk reduction efforts (R. U. Jayasekara *et al*., 2023).

Role of Academia in Disaster Preparedness

Research institutions and academics, working with the government, play a role in providing the necessary scientific data and analysis (Graham *et al*., 2022). Academics play a role in designing, developing, and evaluating disaster mitigation policies and plans. Academics also contribute to creating disaster mitigation components by integrating mitigation principles into these plans, so that policies are not only reactive but also preventive. In the monitoring and evaluation process, academics assess the extent to which disaster mitigation plans are implemented, identify the strengths and weaknesses of these policies, and provide recommendations for more effective and efficient improvements (Hasbi *et al*., 2023).

Academics can develop holistic and integrated educational programs to ensure that disaster education programs receive the necessary support, good knowledge and can be implemented effectively in the field (Boland *et al*., 2024; Indarjo *et al*., 2022; Nugroho, Istiada, *et al*., 2025). Academics contribute not only through research and curriculum development, but also through teacher training, program evaluation, advocacy, and collaboration with various stakeholders (Seddighi *et al*., 2023). teacher training, program evaluation, advocacy, and collaboration with various stakeholders (Seddighi *et al*., 2023). In addition, the role of academics in disaster preparedness through research activities and community service activities, they are able to develop various programs to increase village resilience to multi-disaster threats, starting from the village or from elementary and secondary schools in the village. Resilience to multi-disaster threats is seen as a strategic approach, namely starting from building commitment, policies and regulations, planning, budgeting, risk assessment, teamwork, coordination, standard operating procedures, technical guidelines, monitoring and evaluation, resource mobilization, infrastructure, information systems, assembly points, safe zones, sister schools, curriculum integration, integration into learning activities, training program simulations, trained teachers, information dissemination, student cadres, and safety competitions (Widowati *et al*., 2021, 2023).

Role of Non-Governmental Organizations in Disaster Preparedness

A study conducted in Thailand highlights the crucial role of non-governmental organizations in enhancing community-based flood preparedness for the elderly. Through various initiatives and interventions, non-governmental organizations help ensure that vulnerable elderly populations have access to the education, resources, support, and networks needed to cope with and recover from disasters. The active role of non-governmental organizations in advocacy and policy change is also crucial to create a safer and more resilient environment for the elderly in Thailand (Krongthaeo *et al*., 2021). Initiatives undertaken by non-governmental organizations not only enhance the capacity of local communities to cope with disasters but also strengthen overall disaster management systems in the region. The formation of Disaster Preparedness Groups empowers community members to take an active role in disaster planning and emergency response efforts on Mount Merapi, Indonesia (D. Y. Hermawan *et al*., 2023; Nugroho, Nisa,

et al., 2025). Communities are encouraged to use locally available resources for disaster preparedness, including using local materials to build safer homes and create community-based emergency response kits (A. Hermawan *et al*., 2024).

The flexibility of non-governmental organizations in innovating together with communities is one of the advantages optimized in finding new approaches or methods in efforts to improve disaster preparedness. Collaboration involving communities and non-government organizations improves effective communication, leadership, transparency, and technology optimization (Nyadenga & Davis, 2023; Windraswara, 2009). The results of piloting that produce updates become models that can be further developed or adopted by the government, and applied to wider areas.

Role of Media in Disaster Preparedness

The Nepalese government has adopted modern technology to improve the effectiveness of disaster management, like the use of Geographic Information Systems (GIS), weather monitoring tools, and mobile applications to inform the public about potential threats and provide evacuation guidance (Vij *et al*., 2020). Overall, the role of the media in investigating storms Ciara and Dennis shows that effective communication and rapid dissemination of information can help reduce the impacts of disasters and improve public preparedness (Jardine *et al*., 2023). Through social media, people can report local situations, request assistance, and provide direct feedback to those responsible (Zander *et al*., 2022). Research on the use of technology in disaster preparedness found that Internet of Things (IoT) sensors can be applied to monitor environmental conditions, such as water levels during floods or ground vibrations before earthquakes. To identify disaster risk patterns and trends, big data analysis from various sources can be used to design more effective mitigation strategies. Virtual Reality (VR) and Augmented Reality (AR) based simulations can help people understand disaster situations and evacuation drills, as well as increase readiness to face real disasters. Collaboration between technology and media can produce more effective and inclusive disaster responses (Latvakoski *et al*., 2022).

Conclusion

Personal relationships, individual motivation, organizational response, and positive community relations are key to providing reproductive health services during emergencies. Governments play a central role in strengthening policies, decentralizing authority, adopting technology, building capacity, and collaborating with various stakeholders. The private sector also plays a vital role in providing the resources, innovation, and technology needed for disaster preparedness and mitigation. Academics contribute through research, policy development, and education, while non-governmental organizations strengthen community preparedness through advocacy, resource mobilization, and building local capacity. The collaboration between media and technology also plays a role in producing more effective and inclusive disaster responses. Overall, the success of disaster preparedness depends on strong cooperation and coordination among all stakeholders. Each stakeholder has a unique and complementary role in detecting, disseminating information, and responding to multi-hazard threats, including biological outbreaks. Strong pentahelix collaboration among all stakeholders contributes to minimizing the impacts of disasters and accelerating the recovery of critical infrastructure.

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KEMAS 21 (2) (2025) 423-433

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

The Role of Decentralized Health Systems in Shaping Service Quality: A Systematic Review in Low- and Middle-Income Countries

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Article Info

Article History:
Submitted: June 2025
Accepted: September 2025
Published: October 2025

Keywords:
Decentralization;
Health Systems;
LMICs; Service Quality

DOI
https://doi.org/10.15294/kemas.v21i2.29250

Abstract

Decentralization has emerged as a prominent strategy for health sector reform in low- and middle-income countries (LMICs), aiming to enhance service quality, efficiency, equity, and responsiveness. This study systematically reviews literature published between 2021 and 2025 to explore the role of decentralized health systems in shaping healthcare service quality across LMICs. Using PRISMA 2020 guidelines, 20 eligible studies were identified and analyzed from databases including PubMed, Scopus, Web of Science, and Google Scholar. Thematic synthesis of findings reveals mixed outcomes: while decentralization improves local responsiveness, enhances community engagement, and strengthens health system performance in some settings, it also exacerbates disparities in others due to uneven institutional capacity, limited fiscal resources, and fragmented coordination. Key performance areas identified include human resource deployment, financing, access to services, and equity in service delivery. The study emphasizes the significance of local capacity-building, efficient resource allocation, and integrated planning in attaining sustainable and equitable healthcare improvements within decentralized systems. This review provides practical insights for policymakers aiming to align decentralization strategies with health equity and service quality objectives.

Introduction

Over the past few decades, decentralization has become a prominent reform strategy in the health systems of low- and middle-income countries (LMICs). Decentralization has been undertaken as part of health-care reform measures in both developed and developing nations to improve access to care, promote efficiency, equity, and quality, and strengthen oversight (George *et al*., 2023). This global movement involves delegating planning or service delivery responsibility from national to local governments, or from big to district facilities. The decentralized health system is defined as the movement of primary decision-making responsibility and authority for health care, such as planning, budgeting, and financial management, from the national government or a large unit of local government to a smaller organization closer to the community (Kesale *et al*., 2022). Decentralization encompasses various approaches such as de-concentration, where responsibilities and authority are shifted from the central government to regional or district levels within the same ministry; devolution, which involves the transfer of powers to lower tiers of government; delegation, wherein semi-autonomous bodies are created to undertake roles previously managed by the Ministry of Health; and privatization, where private entities take over ownership and operational control (Noory *et al*., 2024). In the medical field, decentralization is primarily implemented as a strategy to enhance system performance and

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pISSN 1858-1196
eISSN 2355-3596

improve the quality and efficiency of healthcare service delivery.

Many countries have had difficulty in implementing and scaling up decentralization due to issues of availability, price, and service quality. Studies have found no or limited increase in service quality following decentralization (Noory *et al.*, 2024; Rushton *et al.*, 2021). In other studies, certain countries have witnessed significant positive progress as a result of health system relinquishment; in other situations, a decentralised health system has been recentralised due to the perceived failure of the reform. However, mixed evidence may reflect not only different country experiences, but also significant differences in the types of decentralisations studied, methodologies used to assess the impact, and health system concepts/components covered (Sapkota *et al.*, 2023). Furthermore, the precise consequences of decentralization on the performance of healthcare systems are little understood.

Given the diversity of contexts and decentralization models across LMICs, a comprehensive and systematic review of the existing literature is needed to synthesize current findings and identify consistent trends or gaps. Understanding how and under what conditions decentralization contributes to service quality is crucial for policymakers, especially in countries striving to achieve universal health coverage and reduce health inequalities. This study aims to systematically review the relationship between health decentralization and the quality of health services in LMICs. By doing so, it seeks to inform ongoing reforms and guide more effective implementation of decentralization policies in the health sector.

Methods

This research strategy involves conducting a systematic review of the literature. The systematic literature review (SLR) method describes findings from studies published in journals for a specific area of research and inventing originality (Mengist *et al.*, 2020). The author used the Preferred Reporting Items for Systematic Reviews and Meta-analyses

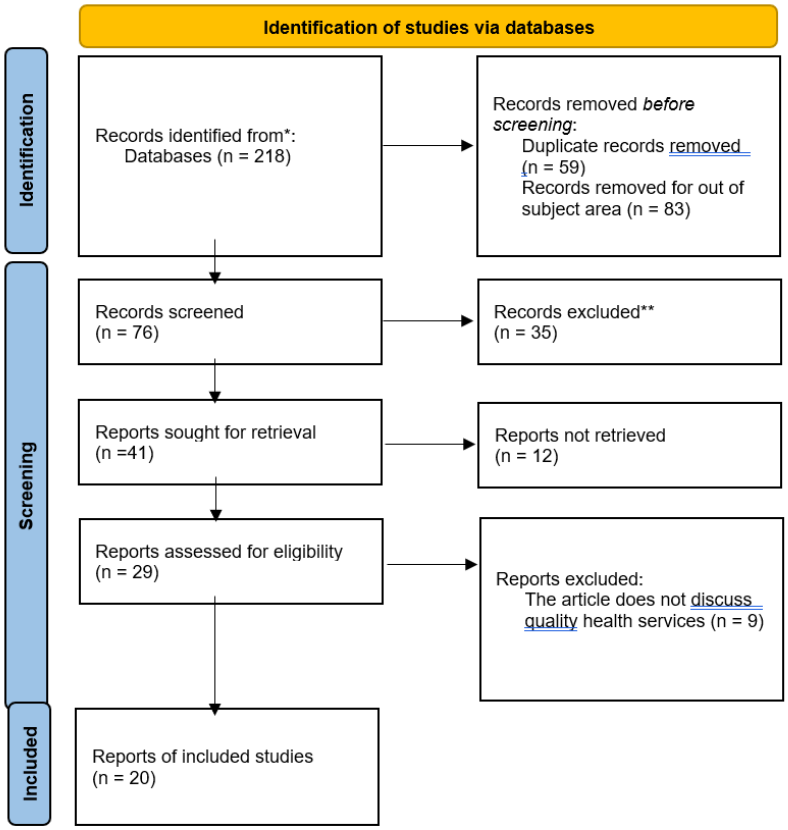

Figure 1. 2020 PRISMA Methods

(PRISMA) 2020 to ensure systematic literature reviews that are transparent, reproducible, and scientifically adequate (Page *et al*., 2021). A comprehensive literature search was conducted using electronic databases including PubMed, Scopus, Web of Science, and Google Scholar. The search covered articles published from 2021 to 2025 using a combination of keywords such as *"health decentralization"*, *"service quality"*, *"healthcare delivery"*, *"low- and middle-income countries"*, and *"LMICs"*. The following criteria were used in selecting the qualifying articles: (i) The article had to be on the impact of decentralization on quality health care; (ii) it had to be original published articles; (iii) it had to be conducted in lower and middle-income countries as defined by the World Bank; (iv) Written in English and (v) Article published between 2021 and 2025. Articles were excluded if they: (i) focused on decentralization outside the health sector; (ii) were conceptual, opinion-based, or commentary articles; (iii) were not accessible in full text. Data extraction was applied to determine which data were involved in the study, which included many of the variables used to evaluate research papers (Nussbaumer-Streit *et al*., 2023). Data was analyzed using content analysis, which aids comprehension by examining the text of each article and its literature references (Popenoe *et al*., 2021). Data analysis entailed collecting and combining information about references, country, population, intervention, outcome, and study design. Figure 1 illustrates the flow diagram of the PRISMA method.

Results and Discussion

Table 1. Characteristics of Included Studies

No.	Ref	Country	Population	Intervention	Comparison	Outcome	Study Design
1.	Rushton *et al*., 2021	Nepal	Nepal Health Systems	The effects of changing Nepal's constitution towards a federal system	Health systems from a unitary to a federalised structure	Changes in the structure, organization, and performance of the health system	Longitu dinal
2.	Dodd *et al*., 2021	Phillipines	Community health worker	Health system decentralization and its influence on governance and administration of CHW programs	Differences across geographic settings (inter-municipal comparisons); no formal control group, but variation between cities/provinces acts as an implicit comparison	Variations in CHW experiences, quality of training, financial/ human resource allocation, and political influences on program governance	Quali tative
3.	Setiawan *et al*., 2022	Indonesia	Local government	Local government capacities	Three types of capacities	Administrative, fiscal, and political complementary and effectively improve the local government's achievement in delivering public services.	Quanti tative

4.	Noory *et al*., 2024	Sudan	418 household members	Implementation of the healthcare decentralization policy in Sudan	Perceptions and conditions of access, affordability, and quality of healthcare before decentralization	Perceived decline in access, affordability, and quality of healthcare services after decentralization, increased privatization, closure of facilities, and reduced capacity of devolved facilities	Mixed methods
5.	Birru *et al*., 2024	Lesotho	Healthcare workers	Lesotho's Primary Health Care Reform (LPHCR) is a decentralization initiative transferring healthcare management from the central Ministry of Health to district-level authorities.	Pre-reform centralized healthcare management	Perceived impact of decentralization on the six WHO health system building blocks: service delivery, health information systems, access to essential medicines, health workforce, financing, and leadership/ governance.	Quali tative
6.	Atisa *et al*., 2021	Africa	Africa	Decentralization	Impact decentralization	Identification of sustainability outcomes in decentralized governance—economic development, environmental protection, social equity, reduced civil conflict, improved living standards	Quali tative
7.	Maket & Naibei, 2025	Kenya	23 Kenyan counties	Fiscal decentralization	Variation across counties in levels of fiscal decentralization and GDP; no centralized control group, but comparative effects across differing fiscal capacities	Availability of healthcare resources: number of medical personnel and hospital beds per 10,000 people	Quanti tative
8.	Singh *et al*., 2024	India	18 non-special category states of India,	Fiscal decentralization	Variation across states and over time in levels of fiscal decentralization and institutional quality (no explicit centralized control group)	Public service delivery outcomes in the health and education sectors	Longi tudinal

9.	Feldhaus *et al*., 2023	India	Health managers	Decentralization	Variation in levels of decision space and institutional capacity across different districts and blocks	Decentralization improves effectiveness and efficiency	Mixed methods
10.	Siburian, 2024	Indonesia	Indonesian provincial-level data	Decentralization	Decentralization and health outcome	Local governments that implement unique local health programs recognized under decentralization laws can improve regional health outcomes. The findings also suggest that ethnic diversity harms regional health outcomes.	Quanti tative
11.	Bojanic & Collins, 2021	OECD and non-OECD countries	OECD and non-OECD countries	Decentralization	Countries or periods with lower levels of decentralization;	Income inequality, including its variation with economic development and decentralization mix	Quanti tative
12.	Cao *et al*., 2023	China	Chinese local governments	Fiscal decentralization	Variation in levels of local government debt and fiscal decentralization across regions and over time	Public health outcomes and the bidirectional effects between fiscal decentralization and local government debt	Mixed methods
13.	Chen *et al*., 2021	Uganda	Managers	Decentralization	Comparison between de jure (policy-based) and de facto (reported) decision space, and between facility types (e.g., large vs. small facilities)	Managerial performance indicators, including essential drug availability, performance management, and quality improvement	Quanti tative
14.	Dougherty *et al*., 2022	OECD Countries	OECD Countries	Administrative decentralization in healthcare decision-making and expenditure assignment across levels of government	Different levels of decentralization (centralized, moderately , and decentralized, highly decentralized systems)	Health care spending levels and life expectancy	Quanti tative
15.	Bossert *et al*., 2022	Colombia and Chile	Municipalities in Colombia and Chile	Health system decentralization and financial reform policies	Equity of funding allocation	Equity in health system funding allocation; sustainability of equitable funding over time	Longi tudinal

16.	Moner-Girona *et al*., 2021	Sub-Saharan Africa	Rural healthcare facilities	Electrification of health facilities	Current state of unelectrified health facilities vs. electrified scenarios using PV systems	Improved healthcare access (reduced travel time by ~50 minutes for 281 million people); cost analysis of PV installation and operation (EUR 484 million investment)	Quanti tative
17.	Miranda-Lescano *et al*., 2023	57 developed and developing countries	57 developed and developing countries	Central and subnational government expenditure on health and education	Variations in levels of government spending across countries and over time	Human Development Index (HDI) and its dimensions: life expectancy, education, and income	Quanti tative
18.	Gadisa, 2022	Ethiopian	Ethiopian health sector	Decentralization	Health sector condition	improved financial mechanisms	Quali tative
19.	Joshi *et al*., 2023	Sub-Saharan Africa	Health care workers	Decentralization	Comparison between centralized vs. decentralized service delivery	Acceptability of decentralized childhood TB diagnosis among HCWs	Quali tative
20.	Ajisegiri *et al*., 2021	Nigeria	National and subnational health authorities	Implementation of national NCD policies	Comparison between national-level policy intent and subnational-level implementation effectiveness	Alignment of NCD policy with decentralized structures; effectiveness of coordination, financing, and integration into primary healthcare (PHC); progress toward national NCD targets	Quanti tative

Sources: Author's analysis of cited studies in the table

Decentralization produces diverse and distinct reactions, with more positive benefits in more developed regions compared to less developed ones. The impacts varied depending on the level of growth of subnational governments, their available resources, demographic factors, the design and management of health systems, and the resources redistributed during the decentralization process (Bojanic & Collins, 2021). More significant benefits were identified in the more developed regions (south). In contrast, the northern areas, defined by disadvantaged cities with limited basic infrastructure and resources, had less obvious consequences of decentralization. Healthcare accessibility challenges, such as cost and transportation concerns, were more common in the south, particularly in less developed regions. This evidence highlights the importance of healthcare accessibility, encompassing factors such as travel distance and time (Oliveira *et al*., 2023). This underscores the importance of accessibility as a core element of health equity, especially in geographically and economically marginalized communities.

Decentralization negatively impacted the availability of resources and access to healthcare, contributing to greater disparities among population groups (Noory *et al*., 2024). The misallocation of financial resources led to a disjointed and inequitable health system, where access, utilization, and resource availability—as well as cost control—were closely tied to the economic status of each region (Qin *et al*., 2024). Wealthier areas were better positioned to increase their funding capacity, thereby deepening the divide between affluent

and disadvantaged areas (Haemmerli *et al*., 2021). This deepening divide illustrates that decentralization alone is not sufficient to ensure universal health coverage.

The closeness between local authorities and the communities they serve enables subnational governments to recognize and respond more effectively to the specific health service needs of their populations. This localized understanding is crucial for effective resource allocation and contributes to enhancing overall population health. Policymakers hold a central responsibility in shaping health strategies (Sigüenza & Artabe, 2022). When healthcare delivery costs are aligned with regional demographic and structural factors, it can lead to significant gains in system efficiency (Mbau *et al*., 2023). In Indonesia, for example, local governments are increasingly forming strategic partnerships with BPJS Kesehatan, the national health insurance agency, to co-finance and expand coverage. Contracts are utilized as tools for health service purchasing, though they must be closely monitored to avoid inefficiencies (Puspandari *et al*., 2025). However, some gaps persist, such as the failure of the JKN scheme to consistently integrate reproductive health and contraceptive access into service delivery, undermining long-term public health objectives (Wahyudi *et al*., 2022). Strengthening the capacity of local governments to analyze and act on these needs is therefore critical to achieving more equitable and efficient health outcomes. In the healthcare sector, delivering patient-centered care is vital for enhancing results and ensuring favorable experiences for individuals (Satoto *et al*., 2025). Healthcare providers willing to re-refer their patients to the hospital are the ones who engage with it. Therefore, to increase the willingness to re-refer patients, hospital management must foster stronger engagement with referring healthcare providers, especially by improving communication and coordination between specialists and primary care practitioners (Wijaya & Antonio, 2024). This collaborative approach not only enhances continuity of care but also strengthens the effectiveness of referral networks under the decentralized system.

Variations in community preferences also reflect unequal service environments. In suburban areas of Java, families predominantly choose formal medical facilities such as hospitals and Puskesmas. Conversely, many rural or remote populations still depend on traditional medicine (Pakaya *et al*., 2024). These differences indicate that, beyond financing and infrastructure, cultural and behavioral factors must be incorporated into decentralized health strategies to ensure inclusiveness and effectiveness.

Decentralization also intersects with social determinants of health. Local governments often control sectors such as education, sanitation, and infrastructure, all of which impact health outcomes. However, budget constraints frequently lead to ranking of physical infrastructure over less visible but equally critical investments, such as nutrition programs or preventive care. For example, decentralized nutrition policies—such as front-of-package labeling to prevent non-communicable diseases—are only effective when adequately funded and implemented at the local level (Siyam *et al*., 2025). Without these capacities, the planned preventive public health benefits may not be realized, and health inequities may develop. Furthermore, decentralized regulation of food labeling may result in fragmented policy enforcement, especially in areas with weak governance or limited monitoring infrastructure. It is particularly problematic considering the growing prevalence of obesity and diet-related disorders, which disproportionately affect low-income areas.

The degree of regional development is considered a key determinant in achieving improved health service outcomes. In contrast to more advanced subnational governments, less developed regions often lack sufficient technical expertise, administrative infrastructure, and managerial competence (Bossert *et al*., 2022). These limitations are further compounded by restricted financial resources, making it difficult for them to manage and deliver health services effectively. As a result, these areas face heightened vulnerability and are at greater risk of systemic inefficiencies (Oliveira *et al*., 2023). To address this imbalance, it is essential to implement targeted interventions that strengthen institutional capacity, enhance fiscal

support, and foster local leadership to improve the quality and accessibility of healthcare services.

Several studies included in this study found that decentralization—particularly devolution, which transfers responsibility to elected local governments—can result in more responsive and needs-based service delivery. Decentralization, by moving decision-making closer to the community, typically enables the development of locally relevant health initiatives, enhances oversight, and facilitates faster responses to health emergencies (Dodd *et al*., 2021; Noory *et al*., 2024; Setiawan *et al*., 2022). Decentralization—when accompanied by sufficient autonomy, resource control, and management capacity—can significantly improve service quality and health outcomes (Birru *et al*., 2024).

This complexity is demonstrated by the impact of decentralization on public service delivery in Indonesia's health infrastructure sector. A study of analytical, operational, and political capacities revealed that none of the three characteristics alone significantly improved service outcomes (as assessed by sanitation coverage). Furthermore, political capacity—defined by legislative oversight and local political behavior—sometimes had a negative impact, implying that unrestrained political authority can damage service delivery. Nonetheless, synergy across these dimensions is critical: when analytical, operational, and political capacities interact, they can strengthen one another and improve government effectiveness (Setiawan *et al*., 2022).

Decentralization has various advantages, including empowering community members to participate in health care delivery. By engaging in CHW programs, CHWs motivated by a desire to care can experience a sense of fulfillment, develop their relationships and networks, enhance their standing within their communities, and acquire new health-related skills and knowledge. Some argue that decentralization in the Philippines helps democratize healthcare by increasing community participation, responsiveness to local problems, and the inclusion of marginalized views. However, obtaining these potential benefits is a challenging process, with some healthcare workers and non-governmental organizations (NGOs) describing the Philippines' current devolution of healthcare as ineffective in improving access, efficiency, and the quality of health services (Dodd *et al*., 2021). In Lesotho, by contrast, decentralization led to concrete improvements in primary care—driven by stronger district leadership, data-informed decision-making, and better procurement of essential supplies (Birru *et al*., 2024).

Fiscal decentralization adds another layer of complexity. Fiscal Decentralization in Kenya may exacerbate socioeconomic disparities, as evidenced by limited access to healthcare resources. Furthermore, the study reveals that county revenue and county gross domestic product have a significant impact on the availability of healthcare resources, with higher county economic productivity benefiting the availability of healthcare resources. In contrast, lower county revenue acts as an impediment (Maket & Naibei, 2025). Similarly, in China, local governments are responsible for funding infrastructure, healthcare, education, and the development of public services. This obligation often leads to a disconnect between fiscal power and accountability, compelling local governments to incur substantial debt to cover funding gaps (Cao *et al*., 2023). This misalignment between fiscal responsibility and accountability poses risks for long-term sustainability.

Moreover, the effectiveness of fiscal decentralization is closely tied to the broader governance environment. Fiscal decentralization will be most effective if an environment is created that prioritizes judicial independence, provides access to justice for marginalized populations, promotes alternative dispute resolution mechanisms, reduces case backlogs, and leverages technology for increased accessibility (Singh *et al*., 2024). For example, healthcare decentralization in Sudan has undoubtedly hindered the central goal of reducing public health risks, particularly among the most vulnerable populations. Access to healthcare has been claimed to have declined due to facility closures, reverse service transfers, and inadequate capacity in devolved facilities. Finally, privatized services

were reported to be strengthened as a result of healthcare decentralization (Noory *et al*., 2024). Decentralization in the Philippines is also criticized more broadly for limiting the state's role, exacerbating inequalities between communities, and increasing the influence of potentially corrupt local political leaders (Dodd *et al*., 2021). Decentralization in Africa often fails to address the triple bottom line of sustainability, which encompasses economic, social, and environmental prosperity that meets present demands without depriving future generations in indigenous-populated regions (Atisa *et al*., 2021). Without addressing structural inequities, decentralization risks becoming a vehicle for fragmentation rather than reform.

Conclusion

This systematic review concludes that decentralization in LMICs produces varied effects on health service quality, shaped largely by the context-specific interplay of institutional capacity, fiscal resources, and governance structures. While decentralization has the potential to improve efficiency, responsiveness, and access—particularly when local governments are empowered with adequate authority and resources—it can also deepen inequalities when implementation lacks strategic coordination and capacity-building. Evidence suggests that decentralization performs best when aligned with broader health system reforms, supported by clear accountability mechanisms and inclusive planning processes. The sustainability and equity of decentralized reforms depend on political will, sufficient local investment, and strong intergovernmental coordination. For LMICs pursuing decentralization as a pathway to improved service quality and universal health coverage, this review highlights the need to address disparities in local capacity and to embed equity considerations at every stage of reform planning and implementation.

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KEMAS 21 (2) (2025) 434-442

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Giving Moringa Soy Milk on Weight Gain and Upper Arm Circumference of Pregnant Women

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Article Info

Article History:
Submitted: June 2025
Accepted: September 2025
Published: October 2025

Keywords:
moringa oleifera;
moringa soy milk;
nutritional status; pregnant women;
upper arm circumference

DOI
https://doi.org/10.15294/kemas.v21i2.29036

Abstract

Moringa oleifera leaves are a potential source of micronutrients and bioactive compounds in functional foods and nutraceuticals. This study aims to determine the effect of moringa soy milk on pregnant women's weight gain and mid-upper arm circumference (MUAC) as indicators of energy and protein nutritional status. This quasi-experimental study was conducted from February to April 2025 in the working area of the Jatibaru Community Health Center, Bima City. It was conducted on 30 pregnant women in their second to third trimesters with a MUAC <23.5 cm. Respondents were divided into two groups: the intervention group accepting 250 ml/day of moringa soy milk for 28 days, and the control group accepting local supplementary food. Data were analyzed using a paired t-test and chi-square tests. The results showed an increase in body weight of 2.00 kg and MUAC of 0.35 cm in the intervention group ($p<0.05$), higher than in the control group. The content of vegetable protein, iron, calcium, and vitamins in moringa soy milk plays a role in improving the nutritional status of pregnant women. These findings suggest that moringa soy milk may be an effective and affordable dietary intervention to prevent Chronic Energy Deficiency (CED) in pregnant women.

Introduction

Pregnancy is one of the most crucial phases in a woman's life cycle. During this period, nutritional needs increase along with the development of the fetus and the physiological changes experienced by the mother. (Ayushree *et al.*, 2020). A critical indicator during pregnancy is adequate maternal weight gain. Weight gain that does not comply with medical recommendations can trigger various pregnancy complications, such as preeclampsia, gestational diabetes, and premature birth (WHO, 2020). Research by Parrettini *et al.* (2020) and Tran *et al.* (2019) Shows that most pregnant women do not meet the recommendations for weight gain and nutritional intake, which can negatively impact the baby's birth weight and increase the risk of pregnancy complications such as preeclampsia, gestational diabetes, and premature birth. Therefore, monitoring the nutritional status of pregnant women is essential in efforts to reduce maternal and infant morbidity and mortality.

Chronic Energy Deficiency (CED) in pregnant women is still a high public health problem in Indonesia and other developing countries. The prevalence of CED in the study in Ethiopia was 28.7% (Dagne *et al.*, 2021), Nigeria 15.4%, Kenya 14.9%, and Gabon 13.4% (Sawadogo *et al.*, 2024). The prevalence of CED in pregnant women in Indonesia is reported to range from 14.8% to 32%, and can even reach 44.4% in some areas. It shows that it is still above the threshold of a public health problem (Izzati and Mutalazimah, 2022). CED in pregnant women is caused by an imbalance in energy and protein intake over a long period, which can increase the risk of pregnancy disorders such

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pISSN 1858-1196
eISSN 2355-3596

as anemia, bleeding, abnormal weight gain, and infection (Angraini *et al*., 2023; Harna *et al*., 2024).

Many studies have confirmed that the incidence of Chronic Energy Deficiency (CED) in pregnant women is highly influenced by inadequate nutrition, mainly energy and protein intake (Mahdiah and Tampubolon, 2023). One of the leading indicators for assessing the nutritional status of pregnant women is the Upper Arm Circumference (MUAC). A MUAC of less than 23.5 cm indicates a high risk of CED and is associated with the possibility of giving birth to a baby with low birth weight. In addition to MUAC, weight measurement is also used to assess energy adequacy during pregnancy, because weight gain that is not appropriate for gestational age can be a sign of nutritional problems (Mutalazimah *et al*., 2020).

Maternal nutritional status, especially during pregnancy, plays a crucial role in preventing CED and various health risks to infants (Helmizar *et al*., 2024; Kashyap *et al*., 2023). Research by Wati *et al*. (2024) stated that women of childbearing age who experience CED have a high risk of giving birth to children who also experience CED, and contribute to morbidity, mortality, and low quality of human resources. Meanwhile, Berhe *et al*. (2021) emphasized that maternal nutritional status before and during pregnancy affects the baby's birth weight, with the risk of premature birth or low birth weight (LBW) in mothers with low BMI. Furthermore, Olloqui-Mundet *et al*. (2024) found nutritional needs increase significantly in the second and third trimesters of pregnancy, so access to nutritious food is key to preventing CED.

One of the intervention approaches taken to overcome CED is the provision of additional food based on vegetable protein. In recent years, the consumption of vegetable protein sources like soybeans has increased significantly due to their high protein content and low saturated fat. Soy milk contains fiber, vitamins, and essential minerals such as calcium, magnesium, and vitamin B complex that support fetal growth and maternal health. Soy milk is also a necessary alternative for pregnant women who are lactose intolerant or at risk of obesity (Ariesthi *et al*., 2021; De and Goswami, 2022).

However, although soy milk has high nutritional value, its protein and micronutrient content can be further improved through fortification. One of the potential food ingredients as a fortifier is moringa leaves (Moringa oleifera). Moringa leaves contain high protein, essential amino acids, iron, calcium, and vitamins A and C. Previous studies have shown that consuming moringa can improve the nutritional status of children and improve protein intake in vulnerable groups (Srikanth *et al*., 2023; Chabibah *et al*., 2023). The combination of soy milk and moringa is a nutritional innovation used in nutritional recovery programs, including for pregnant women.

Providing Supplementary Feeding of biscuits often does not deliver optimal results, due to problems such as nausea and vomiting in pregnant women, irregular distribution, and lack of social support (Rahmiati, 2023). Therefore, alternative nutritional interventions that are highly nutritious, organoleptically acceptable to pregnant women, and producible locally are needed. Efforts to modify biscuit formulas, for example, by adding local ingredients such as purple sweet potatoes, cowpea sprout flour, sorghum, or anchovies and moringa leaves, have been shown to increase nutritional content, taste variation, and acceptability, so that it is expected to reduce boredom and improve the effectiveness of interventions (Picauly *et al*., 2023).

Several studies have shown that pregnant women's consumption of Moringa oleifera leaves is generally safe and does not cause significant side effects. Dantas *et al*. (2024) found that supplementation of Moringa leaf flour in pregnant rats did not cause weight disorders, abortions, or mutations in their offspring, and instead supported children's cognitive development. In a study by Ofulue and Ebomoyi (2023), the acute toxicity test of Moringa leaf alkaloid extract also showed no deaths or pregnancy disorders, and pregnancies continued normally in the treated group. In addition, several human studies outlined that Moringa leaves can increase hemoglobin levels and nutritional status of pregnant women without significant gastrointestinal side effects

(Ashfaq *et al*., 2024; Hadju *et al*., 2020; Usman *et al*., 2025; Yuliastuti and Kurnia, 2022). Thus, Moringa leaves have the potential to be an alternative food supplement that is highly nutritious and well-tolerated by pregnant women, especially for those who experience problems when consuming other supplements (Hadju *et al*., 2020; Hajar *et al*., 2024).

Previous studies have shown that moringa soy milk-based interventions in toddlers can significantly increase body weight and nutritional status (Chabibah *et al*., 2023). It opens opportunities to develop similar products for pregnant women with special needs as an alternative to supplementary feeding. In addition, moringa soy milk has advantages in terms of sustainable raw materials and low production costs, so that it can be integrated sustainably into community nutrition programs. Until now, few studies have specifically examined the effect of moringa soy milk on pregnant women's weight and upper arm circumference. Monitoring these two indicators is crucial to assessing the effectiveness of nutritional interventions in the short term. This study aims to determine the effect of moringa soy milk on increasing pregnant women's weight and MUAC size as a representation of energy and protein nutritional status.

Method

This study employs a quasi-experimental design with a pretest-posttest approach and a control group. The study took place at the Jatibaru Health Center, Bima City, from February to April 2025. The study population consisted of all pregnant women recorded in the Antenatal Care (ANC) visit book in August 2024. A sample of 30 respondents was selected non-probably through a purposive sampling technique, which was divided into two groups: the intervention and the control groups. Each group consisted of 15 respondents. The inclusion criteria in this study included pregnant women in the second and third trimesters, MUAC <23.5 cm, and willingness to participate in the entire series of studies. The exclusion criteria included pregnant women in the first trimester, having chronic diseases, taking certain medications or supplements, or refusing to follow the research protocol. Respondents who were not compliant or experienced conditions that prevented them from continuing were categorized as dropouts.

The intervention group was given 250 ml of moringa soy milk daily for 28 days. This milk is formulated from 33 g of dried soybeans, 3.5 g of moringa flour, 10 g of sugar, and 250 ml of water. Meanwhile, the control group only received local supplementary food from the health center program during the same period. Before and after the intervention, body weight and MUAC were measured using a Scale brand digital scale with an accuracy level of 95–98%. To monitor compliance, researchers provided daily reminders via WhatsApp and periodic home visits, and asked respondents to fill out a 24-hour food recall sheet daily. The respondents' families also assisted in monitoring milk consumption as quality control participants.

This study has obtained ethical approval from the Health Research Ethics Committee of the Faculty of Public Health, Hasanuddin University, Makassar, with protocol number 13125092014. Data was analyzed univariately to describe the characteristics of respondents and bivariately to assess the effectiveness of the intervention. The chi-square test was used to compare characteristics between groups, and the paired t-test was used to measure changes in the same group before and after the intervention.

Result and Discussion

This study used moringa soy milk that had been measured for nutritional content in the Food Chemistry Laboratory of the Faculty of Animal Husbandry, Hasanuddin University. The results found that protein was 5.75 mg, fat was 0.25 g, and carbohydrates were 25.62 g in 250 ml of moringa soy milk (Table 1). Other studies that have developed soy and moringa-based drinks have also shown that adding moringa leaves to soy milk can significantly increase protein, fat, and carbohydrate content, depending on the proportion of moringa used. A study by Matabura and Rweyemamu (2022) found that the increase in protein, fat, and carbohydrate levels can reach 49.77%, 8.59%, and 114.56% as the amount of moringa leaves added to soy milk increases. The increased protein, fat, carbohydrate, and mineral content

Table 1. Results of Macronutrient and Micronutrient Measurements of Moringa Soy Milk per 250 ml

Nutrition	Total Content
Macronutrients	
Protein	5.75
Fat	0.275
Carbohydrate	25.625
Micronutrients	
Calcium (mg)	131.93
Phosphorus (mg)	231.4
Iron (mg)	3.65
Sodium (mg)	73.19
Potassium (mg)	253.81
Copper (mg)	0.62
Zinc (mg)	1.32
Vitamin B1 (mg)	0.18
Vitamin B2 (mg)	0.03
Vitamin B3 (mg)	0.61

Source: Primary Data, 2025

Table 2. Respondent Characteristics (n=30)

Respondent Characteristics	Intervention (Provision of Moringa Soy Milk) (n=15)		Control (Provision of Local Supplemental Food) (n=15)		p-value*
	n	%	n	%	
Education					
Junior High School	0	0	3	10	
Senior High School	9	30	10	33.33	0.800
Bachelor	6	20	2	6.67	
Age					
<20 or >35 Years	3	10	3	10	0.674
20-35 Years	12	40	12	40	
Job					
Civil Servant	3	10	2	6.67	
Self-Employed	4	13.3	3	10	0.754
Housewife	8	26.67	10	33.33	
Gravida					
Primigravida	7	23.33	6	20	0.500
Multigravida	8	26.67	9	30	

* Chi-Square Test

Source: Primary Data, 2025

Table 3. Effect of Giving Moringa Soy Milk on Increasing Body Weight and Upper Arm Circumference of Pregnant Women

Variables	Mean ± SD		Increase	p-value*
	Pre Test	Post Test		
Weight				
Intervention (n=15)	43.86 ± 1.736	45.86 ± 1.818	2.00	0.000
Control (Local Supplemental Food Provision) (n=15)	43.21 ± 2.615	44.75 ± 2.361	1.54	0.000
MUAC				
Intervention (n=15)	21.87 ± 0.934	22.23 ± 0.938	0.35	0.000
Control (Local Supplemental Food Provision) (n=15)	21.42 ± 1.130	21.57 ± 1.170	0,14	0.318

* Paired t Test
Source: Primary Data, 2025

in soy milk and moringa can help overcome the problem of malnutrition (Ponka *et al*., 2022). The characteristics of the respondents in this study, both intervention and control groups, were homogeneous. Most respondents were aged 20–35, had a high school education, worked as housewives, and were multigravida. The Chi-Square test on age, education, occupation, and parity showed a p-value > 0.05, indicating no significant difference between groups, thus both groups could be compared equally in further analysis (Table 2).

This study showed a significant increase in body weight and MUAC in the intervention group after being given moringa soy milk, with a weight gain of 2.00 kg and MUAC of 0.35 cm ($p < 0.05$). Meanwhile, the control group also experienced an increase in body weight of 1.54 kilograms ($p < 0.05$), but the rise in MUAC of 0.14 cm was not significant ($p > 0.05$). The greater increase in the intervention group indicates the effectiveness in improving pregnant women's nutritional status (Table 3). It is in line with Matabura and Rweyemamu (2022) who found that moringa-soy drinks containing 30% and 40% moringa leaves can provide an estimated average requirement (EAR) for protein. Pregnant and lactating women can get an EAR for zinc of around 62% and 35% when drinking 600 and 800 ml/day, respectively. Several substances affect body weight. According to a study by Yunita *et al.* (2023), Carbohydrates, protein, and fat are energy sources from food needed to carry out activities. Carbohydrate intake produces energy used by the body in its metabolic processes. A lack of carbohydrates, protein, and fat can cause reduced energy needs. If this continues, the body will become thin, leading to chronic energy deficiency (CED).

The effectiveness of moringa soy milk in improving the nutritional status of pregnant women can be attributed to the high dietary content of soybeans and moringa leaves, such as protein, iron, calcium, and vitamins. Other studies have also shown that moringa-based products, such as yogurt or moringa leaf powder, can increase the content of protein, iron, and other minerals, vital for growth and development, and prevent anemia in pregnant women (Rotella *et al*., 2023). In addition, moringa supplementation during pregnancy is safe and has no side effects, so it can be an alternative, affordable, and easily accessible nutritional intervention, especially in areas with high levels of malnutrition (Ponka *et al*., 2022). Studies in Kenya (Attia *et al*., 2022) and Indonesia (Basri *et al*., 2022) also support the idea that moringa supplementation increases breast milk output, improves blood profiles, and reduces the prevalence of stunting in children born to mothers who received the intervention during pregnancy.

This study find that giving moringa soy milk can increase the weight of pregnant women according to the recommendations set by the Institute of Medicine (IOM) in 2009. Based on IOM guidelines, weight gain during pregnancy is adjusted to the mother's initial nutritional status based on the WHO classification, where underweight mothers are recommended to experience a total weight

gain of 12.5–18.0 kg, normal weight mothers 11.5–16.0 kg, overweight mothers 7.0–11.0 kg, and obese mothers 5.0–8.0 kg. Additionally, in the second and third trimesters, the recommended weekly weight gain ranges from 0.17 to 0.58 kg, depending on the nutritional status category. Giving moringa soy milk contributed to achieving weight gain within the recommended range, thus can help prevent the risk of complications such as fetal growth retardation, low birth weight, premature birth, and increased neonatal morbidity and mortality (Adeoye *et al*., 2023).

In this study, giving moringa soy milk to pregnant women effectively increased body weight as recommended weight gain during pregnancy. This finding shows more optimal results compared to several previous studies that assessed the effectiveness of the Supplemental Food Program in the form of biscuits for pregnant women with Chronic Energy Deficiency (CED). Research by Riandha Feliza *et al*. (2023) and Setyawati *et al*. (2024) showed that even though PMT biscuits had been given, there were still cases of CED pregnant women and insignificant weight gain. The significant increase in MUAC in the intervention group indicates an improvement in energy reserves and nutritional status of pregnant women, which are very important to support fetal growth and prevent pregnancy complications due to malnutrition (Derbo and Debelew, 2024). MUAC is a sensitive indicator for assessing the nutritional status of pregnant women, so this increase indicates the success of the intervention in meeting the mother's dietary needs (Febriza and Idrus, 2023). In terms of composition, moringa soy milk contains high-quality vegetable protein, fiber, and essential micronutrients such as iron and calcium, which play a role in the formation of red blood cells and bone health. The antioxidant content in moringa can also help increase the immune system of pregnant women and support optimal fetal development (Brar *et al*., 2022).

The nutritional content of Moringa leaves can meet ideal dietary needs, improve nutritional status, and support the body's anabolism, so that weight gain occurs (Islam *et al*., 2021). Moringa leaves do not contain harmful substances, so they are safe for consumption by children and adults. Pathophysiologically, weight gain due to consumption of Moringa leaves is mainly caused by increased protein and micronutrient intake that accelerates new tissue synthesis, improved nutritional status that supports optimal growth and development, and the anabolic effects of bioactive content that will enhance body metabolism and increase the efficiency of nutrient utilization (Kashyap *et al*., 2022). Local food-based interventions improve nutritional status and community food security. Zakaria *et al*. (2024) demonstrated that Plumeria rubra ointment effectively relieves mastitis pain in postpartum mothers, highlighting the potential of local herbal ingredients in improving maternal health. Azinar *et al*. (2018) emphasized the importance of local food-based nutrition education for pregnant women to improve consumption behavior during pregnancy, using the Prenatal Class Plus model. From the perspective of health workers, Putri *et al*. (2023) highlighted the role of preparedness of officers in rural areas in supporting the success of local nutrition intervention programs, such as the provision of moringa preparations. Rahman *et al*. (2024) also demonstrated that the consumption of local ingredients such as avocado extract positively impacts community nutritional status, similar to the role of moringa in this study. Furthermore, Tulak *et al*. (2018) emphasized the importance of adapting interventions to local geographic and social conditions for program effectiveness.

Consumption of moringa leaves in capsule, extract, or processed form, such as biscuits, has increased energy and macro and micro nutrient intake in vulnerable groups like pregnant women and children. This increase in nutrient intake supports protein synthesis and body tissue repair, thus contributing to increased muscle mass and subcutaneous fat tissue in the upper arm, as reflected by an increase in upper arm circumference (MUAC) (Fitriahadi *et al*., 2024; Frianti *et al*., 2022). Moringa leaves also increase hemoglobin levels and iron status, which improves oxygen transport to body tissues and supports cell metabolism, including muscle growth (Nur *et al*., 2020). The effect of increasing MUAC from consuming moringa leaves occurs because its

complete nutritional content improves energy intake, protein status, and body metabolism, thus supporting the growth of muscle and fat tissue in the upper arm (Nur *et al*., 2022).

Conclusion

Moringa soy milk is a promising nutritional intervention in improving the nutritional status of pregnant women, especially in cases of Chronic Energy Deficiency (CED). The combination of soybeans and moringa leaves produces a drink with high vegetable protein, iron, calcium, and vitamin content, and is safe to consume during pregnancy. Giving 250 ml of moringa soy milk daily for 28 days showed a significant increase in body weight and upper arm circumference of pregnant women, two important indicators of nutritional status. This effectiveness makes moringa soy milk an alternative supplementary food, which is highly nutritious, affordable, and well-accepted organoleptically by pregnant women. Furthermore, its widespread use in community nutrition programs has great potential to support the achievement of maternal and neonatal health targets, especially in areas with high CED prevalence. However, larger-scale and long-term intervention trials are needed to ensure the safety and sustainability of its benefits. Moringa soy milk appears to be a strong candidate for developing functional food products that support healthy pregnancies and a better quality of life for future generations.

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KEMAS 21 (2) (2025) 443-453

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Screen Time, Anthropometric Parameter, Insulin and Homa IR in Adolescents

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Article Info

Article History:
Submitted: May 2024
Accepted: September 2025
Published: October 2025

Keywords:
Screen time; Adolescents; Anthropometric parameters; Insulin; HOMA IR

DOI
https://doi.org/10.15294/kemas.v21i2.6265

Abstract

Introduction: The rapid integration of digital technology into daily life, particularly among adolescents, has generated increased screen time exposure. This study investigates the effect of screen time on anthropometric parameters, insulin levels, and HOMA IR in adolescents, regarding the increasing concerns about its potential health implications. Methods: A cross-sectional study involving 131 healthy adolescents (aged 12-18) was conducted to assess an anthropometric measurements, blood investigations (lipid profile, fasting blood glucose, fasting insulin), blood pressure, and screen time assessments. Screen time was categorized as recommended, moderate, and heavy. Results and Discussion: The moderate screen time was associated with a higher risk of overweight (OR=5.643), obesity (OR=3.737), insulin resistance (OR=4.116), and metabolic syndrome (OR=2.185). Heavy screen time showed higher risks for being overweight and metabolic syndrome (OR=32.421), but did not correlate significantly with overweight or obesity. The findings suggest a significant association between screen time and adverse health outcomes in adolescents, particularly for moderate and heavy screen time. Heavy screen time demonstrated substantial risks, emphasizing the need for interventions to mitigate potential health consequences. Conclusion: Screen time has noteworthy implications on the health of adolescents, with significant associations observed on anthropometric parameters, insulin resistance, and metabolic syndrome

Introduction

Technology makes human life easier, especially in digital technology. Digital technology and devices have become habitual tools and must-haves in all human life nowadays (Konca, 2022), especially with the development of communication technology, marked by the development of *the interlinked computer networks* (Internet), which diminished physical barriers for the users (Petcu and Gherheș, 2010). These digital technology developments have made young children use this technology regularly in their daily lives, even in school life (Konca, 2022). This technology development has exposed humans, especially children, to longer screen time on electronic or digital devices, including computers, laptops, smartphones, tablets, or other devices with a screen as the medium of communication, virtual interaction, and connected with people (Pandya and Lodha, 2021).

Screen time is time spent on screen devices, including smartphones, tablets, television, video games, computers, or wearable technology (Canadian Pediatric Society, 2019). Nowadays, young children have been exposed to digital devices from birth, and the use of digital media from an early age has increased rapidly (Neumann, 2015). Even educational sites encourage their students to use digital technology (Straker *et al.*, 2018). This phenomenon is also experienced by adolescents, with screen time as the common activity. They spend screen time at least 3 hours

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pISSN 1858-1196
eISSN 2355-3596

per day, such as watching television (57% of them spend an average time of 109 minutes) (Haghjoo *et al*., 2022). Growing evidence notes that screen time is one of the causes of overweight/obesity in modern technology (Priftis and Panagiotakos, 2023). Screen time has a serious impact, including the increase of the obesity pandemic, reduced physical activity, and sleep disturbances (Goswami and Parekh, 2023). The highest risk was cardiovascular disease (Takagi *et al*., 2019). Screen time activity recommendation for children and adolescents was limited to less than 2 hours per day. Yet, more than 50% adolescents access screen time more than that (Haghjoo *et al*., 2022).

Screen time affects body composition, particularly BMI, via sleep, diet, and physical activity (Zhang *et al*., 2022). Screen time is one of the sedentary behaviour with low energy expenditure (< 1.5 metabolic equivalents), which increase the risk factor of metabolic disease (Haghjoo *et al*., 2022). However, population studies still result in inconsistent outcomes in investigating the correlation between screen time and overweight/obesity. A literature review noted that the highest screen time category had 0.7 kg/m^2 higher BMI than lower screen time in children and adolescents, and those with obesity had higher screen time than non-obese by 0.313 hours (Wu *et al*., 2022). The relationship between high and low screen time and the blood pressure, BMI, and waist-to-hip ratio (WHR) was confirmed in adolescents (Oto *et al*., 2021). Another meta-analysis study noted that screen time had no relationship with central obesity, even though the subjects with the highest screen time had a higher waist circumference by 1.23 cm than lower screen time subjects (Ghasemirad *et al*., 2023). Objectives: to investigate the effect of screen time on anthropometric parameters, insulin, and HOMA IR in adolescents.

Methods

A cross-sectional study was conducted in adolescents aged 12-18 years old in Surabaya and Sidoarjo from September 2019 to January 2020, involving healthy adolescents (normal, overweight, and obese) aged 13-18 who studied in Sidoarjo and Surabaya. The subjects in this study should be healthy, not smokers, not consume alcohol or drugs, not have dyslipidemia medication or undergo hormonal therapy, or autoimmune disease, and not have chronic diseases or infectious diseases. Before the study was performed, the researchers must have the head master's permission and clarify the importance of this study in front of the subject's parents. The subjects would participate in this study only when the parents sign informed consents without any coercion, as this study needs blood withdrawal. This study is an open-label one, without any randomization.

The anthropometric measurements included: body height (Seca stadiometer 213®, Seca, Germany), body weight (Seca Robusta digital scale 815®, Seca, Germany), waist circumference (Seca 201 measuring tape®, Seca, Germany), and hip circumference (Seca 201 measuring tape®, Seca, Germany). All the procedures were done when the subjects wore light clothes, without accessories (belt, hairpin, watch, hat, or ponytail) in a standing position. Body weight was measured using a weighing device. When the weighing device reads 00.00, ask the child to stand in the center of the weighing device. Make sure the child is standing upright, eyes/head straight ahead, legs not bent. The interviewer can help the child to stand properly on the scale and reduce unnecessary movements that may affect the weighing result. After the child stands correctly, the weighing device will automatically show the digital weighing result. Ask the child to get off the scale first, and the interviewer should immediately record the result.

Body height measurements were taken using a stadiometer. After the stadiometer is assembled and ready for use, the subject to be measured is asked to remove shoes, sandals, and hats. Then the subject to be measured stands upright on the base with straight legs, heels closed, buttocks and back of the head against the stadiometer, and face straight with a forward gaze. Lower the head slider until it is tight against the top of the head, and then read the number on the scale visible on the stadiometer. The number indicates the height of the subject. The waist and hip circumference measurements were taken using a measuring tape. A measuring tape was wrapped around the waist in a standing straight position without

pulling the stomach. Waist circumference is measured halfway between the lower ribs and the iliac crest. Hip circumference is measured at the largest circumference around the buttocks. Measurement error occurs if the tape is pulled too tight or loose (Eaton-Evans, 2005).

The blood test was taken via the vena cubiti. Before the blood was taken via the vena cubiti in the morning, the subjects were asked to fast for 12 hours (did not have a meal or snack, or sweet beverage after the last supper, except drinking water). The blood was taken by a laboratory technician. After the blood was taken, it was placed in a labelled non-EDTA tube (the label included name, sex, birth date, the date the sample was taken, and the schools' name) as much as 5 ml, and then it was placed in a cooling box for transportation to the laboratory (Kedung Doro Laboratory). The blood investigation includes: lipid profile, fasting blood glucose (FBG), and fasting insulin. Blood pressure was measured in a relaxed sitting position. If the subject is doing physical activity, ask to rest for 10 minutes before the measurement is taken.

1. Use the cuff on the upper arm on the left side.
2. The cuff should be about 2-3 cm above the elbow. Place the cuff directly on the skin, as clothing may cause a weak pulse and result in measurement errors.
3. Tighten the cuff.
4. Place the subject's hands on the table and relax the subject's posture.
5. The cuff should be at the level of the subject's heart.
6. Press the START button to start the measurement.
7. Remain still until the measurement is complete, i.e. the pressure and pulse values are displayed on the monitor.

Screen time was assessed using the World Health Organization-Global School Health Survey (WHO-GSHS), to confirm the duration of screen time activity. The subjects were divided into 3 groups. Recommended screen time (> 2 hours/day), moderate screen time (3-6 hours/day), and heavy screen time (> 7 hours/day). Insulin resistance (IR) was determined using homeostatic model assessment for insulin resistance (HOMA IR), calculated using:

$$HOMA - IR \equiv \left[Fasting\ blood\ glucose\ \left(\frac{mg}{dL}\right) \times insulin\ \left(\frac{uu}{L}\right)\right] \div 405$$

The cut-off value to determine IR was ≥ 5.22 for boys and ≥ 3.82 for girls in pubertal periods (Kurtoglu *et al*., 2010). The subjects were determined as hyperinsulinemic when the fasting insulin ≥15 µU/mL (Güemes *et al*., 2020). Metabolic syndrome (MetS) assessment based on the International Diabetes Foundation (IDF) criteria, namely central obesity (waist circumference > 90th percentile or adult cut-off value) accompanied by at least 2 other component: glucose intolerance (fasting blood glucose or FBG > 100 mg/dL), triglycerides > 150 mg/dL, and HDL-c (high density lipoprotein cholesterol) < 40 mg/dL, hypertension (systole blood pressure > 130 mmHg or diastole blood pressure > 85 mmHg) (Magge *et al*., 2017; Zimmet *et al*., 2007).

This study has been reviewed and registered ethically and was approved by the Ethical Committee of the Faculty of Medicine, Airlangga University, Number 65/EC/KEPK/FKUA/2020. After a test of normality (Kolmogorov-Smirnov) was conducted, one-way ANOVA or Kruskal-Wallis was conducted, followed by a post hoc test (LSD or Mann-Whitney). The correlation between screen time and other variables was conducted using Pearson's or Spearman's Rho correlation. While the categorical parameters were analyzed using multinomial logistic regression to determine the odds ratio, the correlation were analyzed using Cramer's V or Phi.

Results and Discussion

A total of 131 adolescents were recruited after their parents signed the informed consent and received approval from their school. 61.83% adolescents had screen time more than 2 hours/day. However, a study in Malaysia found that the prevalence of excessive screen time in children was 91.4%, which was higher than this study, with an average time of 3.00 h/day(Raj *et al*., 2022). Excessive screen time is strongly associated with friends' screen time (Suchert *et al*., 2016), parents' screen time during weekdays (Ishii *et al*., 2022), higher education, and BMI

Table 1. Subject's Characteristics

Variables	x ± SD (n=131)	Recommended screen time x ± SD (n=50)	Moderate screen time x ± SD (n=66)	Heavy screen time x ± SD (n=15)	p
Age, months old	185.58 ± 16.50	174.56 ± 15.03[a*]	191.35 ± 13.65[a]	196.93 ± 11.94[a]	0.000[1]
Body height, cm	161.76 ± 7.71	158.93 ± 7.592[a*]	163.63 ± 6.81[a]	162.95 ± 9.40	0.004[1]
Body weight, kg	86.61 ± 20.32	80.54 ± 14.96[a*]	90.08 ± 22.72[a]	91.55 ± 20.97	0.025[1]
Body mass index, kg/m^2	33.17 ± 6.78	31.81 ± 4.44	33.64 ± 7.60	35.63 ± 8.72	0.116[1]
BMI-for-age z-score	2.66 ± 1.19	2.67 ± 0.72	2.62 ± 1.46	2.75 ± 1.22	0.097[2]
Height-for-age z-score	-0.64 ± 0.81	-0.58 ± 0.92	-0.66 ± 0.67	-0.79 ± 1.02	0.670[1]
Hip circumference, cm	107.41 ± 13.76	104.83 ± 9.60	108.45 ± 15.46	111.41 ± 16.69	0.182[1]
Waist circumference, cm	98.75 ± 17.00	99.02 ± 12.89	98.63 ± 18.09	98.34 ± 24.15	0.660[2]
LDL-c, mg/dl	117.50 ± 29.13	112.08 ± 28.49	121.65 ± 29.41	117.33 ± 28.92	0.216[1]
Total cholesterol, mg/dl	7.27 ± 5.66	168.34 ± 33.27	181.03 ± 37.42	175.67 ± 34.71	0.168[1]
HDL-c, mg/dl	45.02 ± 9.07	44.00 ± 8.29	45.14 ± 8.96	47.93 ± 11.77	0.337[1]
Triglyceride, mg/dl	110.64 ± 57.45	103.16 ± 55.23	118.06 ± 62.11	102.93 ± 39.25	0.332[1]
Fasting blood glucose, mg/dl	82.75 ± 7.68	80.60 ± 7.69[b*]	83.29 ± 7.31[b]	87.53 ± 7.07[b]	0.006[1]
Systole blood pressure, mmHg	127.82 ± 15.21	123.72 ± 13.44	130.58 ± 15.58	129.33 ± 17.09	0.050[1]
Diastole blood pressure, mmHg	82.05 ± 10.80	82.46 ± 9.22	81.27 ± 11.57	84.13 ± 12.49	0.619[1]
Insulin, µU/mL	23.89 ± 17.76	18.55 ± 15.68[b*]	26.05 ± 16.32[b]	32.18 ± 25.16[b]	0.002[2]
HOMA IR	5.01 ± 4.13	3.85 ± 3.89[b*]	5.42 ± 3.55[b]	7.09 ± 6.04[b]	0.000[2]
Sleep duration, hours/day	6.95 ± 1.27	7.50 ± 1.27[b*]	6.62 ± 1.06[b]	6.59 ± 1.57[b]	0.000[2]

[1]Oneway anova, post hoc LSD; [2]Kruskal Wallis, Post hoc Mann Whitney; [a]Significant between groups (p<0.05), post hoc LSC; [b]Significant between groups (p<0.05), post hoc Mann Whitney.

(Kurniasanti *et al*., 2019). Parents play a crucial role in their children's screen time activity (Raj *et al*., 2022; Xu *et al*., 2015). TV screen time activity decreased in 2002 and 2010. Yet people tend to switch this activity to the computer (Przybylski, 2019). For adolescents now, screen time means social media usage, which could entertain and build connections with others (Ganson *et al*., 2023).

No significant difference in BMI, BMI-for-age z-score, hip circumference, waist circumference, fasting lipid profile, and blood pressure (p>0.05). A study conducted in adolescents produced a contradictory result, as screen time performed a positive dose-response relationship with BMI (percentile), waist circumference, and body fat (Suchert *et al*., 2016). Others stated a positive association between screen time and BMI, skinfold thickness, waist circumference, and physical activity (Dumith *et al*., 2012). However, another study highlighted gender-related findings, in which screen time of more than 6 hours/day was associated with waist circumference in males, not females (Singh *et al*., 2023).

While age, body height, body weight, fasting blood glucose, fasting insulin, HOMA IR, and sleep duration showed at least one pair of groups with significance (p<0.05). Subjects with recommended screen time were younger than subjects with moderate screen time (p=0.000) and heavy screen time (p=0.000). A systematic review showed that screen time correlated positively with children's age, and the increment in screen time by 60 min/day from the age of 11 to 15, or the mid-adolescent phase (Dumith *et al*., 2012). The gender correlation also shows that moderate screen time was prevalent in male adolescents. However, the results seemed contradictory (Shalani *et al*., 2021). Others also found the gender-related aspect of excessive screen time, in which longer screen time was seen in males than females, and the younger ones (14-15 years old) had excessive screen time (De Lucena *et al*., 2015). Trang *et al*. (2013) stated that the average screen time in female adolescents aged 16 years old was 69 minutes/day (min-max 34-95), while male adolescents had longer screen time activity by 78 minutes/day (min-max 48-104) (Trang *et al*.,

2013). However, a study in children showed that screen time did not differ by gender (Belton *et al*., 2021). Gender based differences also found that females had longer screen time than males. Yet, found that the older the subjects, the longer the screen time (Dahlgren *et al*., 2021). A study found that school grade was correlated with screen time. Students in the 6th grade had a higher risk for longer screen time by 1.44-fold than other grades, and being in the 7th grade increases screen time exposure by 1.53-fold (dos Santos Farias *et al*., 2021).

Adolescents with recommended screen time were shorter than subjects with moderate screen time (p=0.001) as they were younger than moderate screen time, and lighter (p=0.012). A study conducted in children aged 2-14 found that children with more than 3 hours//day tend to have excess body weight by 1.20-fold (Cartanyà-Hueso *et al*., 2022), which is in line with these findings. However, adolescent studies found no correlation between screen time and body weight status. Yet, it correlated with age, gender, and type of school (Myszkowska-Ryciak *et al*., 2020). Subjects with recommended screen time also had lower systolic blood pressure compared to moderate screen time (p=0.016). Screen time showed no correlation with blood pressure. However, a study conducted in obese children showed a mild correlation with screen time (Stabouli, 2022), which is in line with this result. But other studies contradicted this finding, as screen time for more than 6 hours/day did not correlate with hypertension (Singh *et al*., 2023). We suspect that the contradictory result of screen time in adolescents is due to specific social media usage by adolescents, as a finding stated that screen time, especially social media use, was associated with attempts to gain weight and lose weight. These behaviour changes were platform-dependent (Ganson *et al*., 2023), resulting in a negative association in which screen time reduced body weight. As for those with a positive association between screen time and body weight gain due to overeating, desire to drink, satiety responsiveness, and reduced physical activity, resulting in a positive effect in BMI (Semar and Bakshi, 2022).

Subjects with recommended screen time also had lower fasting blood glucose (FBG) than subjects with moderate screen time (p=0.048) and heavy screen time (p=0.002). A meta-analysis found that subjects with the highest screen time had a 1.64-fold risk of MetS compared to those with the lowest screen time. Others also found a linear association between screen time and MetS risk, in which every 2 hours of screen time increment will increase the risk of MetS by 1.29-fold (Jahangiry *et al*., 2022). A cohort study found that screen time more than 2 h/day (average screen time of 2.86 ± 0.08 h/ day) increase the BMI by 8 points (22.57 ± 0.13 kg/m^2 to 30.27 ± 0.18 kg/m^2) during 24-year of follow-up, with 43.4% had obesity, 8.4% had diabetes, 31.8% had hypertension, and 14.9% had hyperlipidemia (Nagata *et al*., 2023). This finding is also supported by the statement that childhood screen time at the ages of 5 and 15 years old was associated with the presence of MetS at the age of 45 years old (OR=1.30, 95% confidence interval: 1.08 to 1.58; *p*=0.006), and also associated with low cardiorespiratory fitness (MacDonell and Hancox, 2023).

Subjects with recommended screen time had lower fasting insulin than subjects with moderate screen time (p=0.022) and heavy screen time (p=0.008). On the basis of HOMA IR value, subjects with recommended screen time also had smaller HOMA IR value than subjects with moderate screen time (p=0.001) and heavy screen time (p=0.002). A study conducted in adults showed the highest prevalence of insulin resistance in subjects with long screen time, and correlated with HbA1C (Nightingale *et al*., 2017). However, the study in adolescents showed no significant difference between recommended screen time (2-4 h/day) and the incidence of diabetes mellitus (>4h/day). Adolescents with >4h/day had higher risk of being T2DM by 2.06-fold than adolescents with recommended screen time (Scandiffio and Janssen, 2021). A study found a stronger effect of screen time in boys than girls, in which excessive screen time increases the risk of elevated insulin levels by 2.73-fold and HOMA IR value by 2.42-fold (Hardy *et al*., 2010). The correlation between screen time and insulin resistance was a dose-response in the adult population, which increased HOMA IR value in low, moderate, and high screen time (0.37 ± 0.008, 0.40 ± 0.012, and 0.43 ± 0.012). Waist circumference mediates the effect of screen

time and insulin resistance (Parker *et al*., 2023). However, this phenomenon was not evident in this study. No correlation was seen between screen time and waist circumference, as seen in Table 2.

A cohort study in children with a 2-year follow-up showed that adiposity is a central predictor of insulin dynamics; every 1% increment of body fat will be accompanied by a decrease of insulin sensitivity by 2.9%. This evidence also predicted the 0.5% enhancement in oral glucose tolerance 2 years later (Hardy *et al*., 2010). Screen time was associated with body composition in adolescents; the additional hour screen time per day increase BMI, abdominal subcutaneous fat index, and visceral fat mass (Wu *et al*., 2023). Others found the effect of screen time on percent body fat was evidence in boys, not in girls (Barnett *et al*., 2010). However, we can conclude that screen time increases the risk of insulin resistance via body composition, especially fat distribution. A study conducted in Semarang gave another view as screen time was associated with sugar-sweetened beverage (SSB) consumption in female adolescents, as they had excessive screen time more than 8 hours/day, with an average consumption of SSB by 5 times/week. Types of SSW were powdered drinks, packaged milk, yoghurt, packaged coffee, and carbonated drinks. Those SSW were associated with percent body fat (Setyawati *et al*., 2023).

Subjects with recommended screen time also had shorter sleep duration than subjects with moderate screen time (p=0.000) and heavy screen time (p=0.017). It was stated that excessive screen time is associated with poor quality of sleep and duration via several pathways: displace other activities, suppression of melatonin production due to exposure of bright which lead to circadian disruption, sympathetic regulation which lead to a psychophysiological arousal, and electromagnetic radiation delayed the melatonin production in the pineal gland as it sensed as light (Lissak, 2018; Priftis and Panagiotakos, 2023). Screen time has been proven to disrupt nighttime sleep and lower the sleep consistency in children (Przybylski, 2019).

Table 2. The Correlation Between Screen Time Duration with Anthropometric and MetS Components

Variables	Correlation	
	R	P
Age	0.519	0.000[1]
Body height, cm	0.255	0.003[1]
Body weight, kg	0.173	0.049[1]
BMI, kg/m^2	0.134	0.127[1]
BMI-for-age z-score	0.194	0.026[2]
Hip circumference, cm	0.198	0.023[2]
Waist circumference, cm	-0.039	0.655[1]
LDL-c, mg/dl	0.112	0.201[1]
Total cholesterol, mg/dl	0.135	0.125[1]
HOMA IR	0.298	0.001[2]
Insulin, µU/mL	0.263	0.002[2]
Fasting blood glucose,mg/dl	0.271	0.002[1]
HDL-c, mg/dl	0.109	0.215[1]
Triglyceride, mg/dl	-0.023	0.791[1]
Systole blood pressure, mmHg	0.094	0.285[1]
Diastole blood pressure, mmHg	-0.006	0.946[1]
Height-for-age z-score	-0.088	0.315[1]
Sleep duration, hours/day	-0.317	0.000[2]

Table 2 summarizes the correlation between screen time and anthropometric measurements and MetS components. Screen time was correlated positively with body height (r=0.255, p=0.003), body weight, BMI-for-age z-score and hip circumference. A study in children found a positive correlation between screen time and BMI-for-age z-score and waist circumference, in which the addition of screen time by 1 hour will be accompanied by an increment of BMI-for-age z-score by 0.06 points and 0.4 cm waist circumference (Lee *et al*., 2015).

Screen time correlated positively with HOMA IR value (r=0.293, p=0.001), fasting insulin (r=0.263, p=0.002), and FBG (r=0.271, p=0.002), which means that screen time correlated with the possibility of T2DM. A similar result was also seen in Korean teenagers, in which students with moderate screen time (>2 hours/day) increased the risk of pre-diabetes (blood glucose parameters) by 9.17% (OR=1.942) (Wu *et al*., 2018). In another investigation, the risk of diabetes was increased by 2.06-fold in adolescents with screen time > 4 hours/day (Scandiffio and Janssen, 2021). It seems that there was a change in dietary pattern toward western food during screen time than the Korean healthy diet, which leads to insulin resistance (Lee *et al*., 2013). Screen time duration had a negative correlation with sleep duration (r=-0.317, p=0.000) but performed a positive correlation with age (r=0.519, p=000). A similar result was reported with r_S=- 0.42, p<0.001) for sleep duration, and age (r_s = 0.60, p< 0.001), and screen time became the predictor of sleep disturbance (β =- 0.26, p< 0.001) along with age (β =- 0.20, p< 0.001) (Sourtiji *et al*., 2018).

Table 3. The Correlation Between Screen Time Groups with Anthropometric and MetS Components

Variables	Recommended Screen Time (n=50)	Moderate Screen Time (n=66)	Logistic Regression	Heavy Screen Time (n=15)	Logistic Regression	Correlation	
						Cramer V/ Phi	P
Gender			2.685*		2.243	0.161	0.183
- Male	22 (44%)	40 (60.60%)		7 (46.67%)			
- Female	28 (56%)	28 (42.42%)		8 (53.33%)			
BMI-for-age z-score categories					-	0.489	0.000
- Normal	5 (0.10%)	15 (22.72%)	-	3 (20%)			
- Overweight	30 (60%)	12 (18.18%)	5.643*	0 (0%)			
- Obesity	15 (30%)	39 (59.09%)	3.737*	12 (80%)			
Waist circumference categories			0.651		-	0.130	0.330
- Abdominal obesity	44 (88%)	51 (77.27%)		12 (80%)			
- Normal	6 (12%)	15 (22.72%)		3 (20%)			
Sleep categories			3.296*		2.548	0.278	0.006
- Insufficient	24 (48%)	50 (75.76%)		11 (73.33%)			
- Sufficient	26 (52%)	16 (24.24%)		4 (26.67%)			
HOMA IR categories			4.116*		7.458*	0.277	0.007
- IR	10 (20%)	27 (40.91%)		9 (60%)			
- Non-IR	40 (80%)	39 (59.09%)		6 (40%)			
Insulin categories			1.042		1.566	0.221	0.041
- Hyperinsulinemia	23 (46%)	44 (66.67%)		11 (73.33%)			
- Normal insulin	27 (54%)	22 (33.33%)		4 (26.67%)			
Fasting blood glucose categories			0.221		-	0.244	0.020
- Hyperglycemic	-	-		1 (6.67%)			
- Normal	50 (100%)	66 (100%)		14 (93.33%)			

Variables	Recommended Screen Time (n=50)	Moderate Screen Time (n=66)	Logistic Regression	Heavy Screen Time (n=15)	Logistic Regression	Correlation	
						Cramer V/ Phi	P
Triglyceride level categories			0.716		0.089	0.109	0.461
- Hypertriglyceridemia	18 (36%)	24 (36.36%)		3 (20%)			
- Normal triglyceride	32 (64%)	42 (63.64%)		12 (80%)			
HDL-c level categories			0.668		0.051	0.107	0.471
- Low HDL-c	18 (36%)	31 (46.97%)		7 (46.67%)			
- Normal HDL-c	32 (64%)	35 (53.03%)		8 (53.33%)			
Blood pressure categories			1.181		1.392	0.129	0.336
- Hypertension	27 (54%)	42 (63.64%)		11 (73.33%)			
- Normal	23 (46%)	24 (36.36%)		4 (26.64%)			
The presence of MetS			2.185*		32.421*	0.125	0.358
- MetS	20 (40%)	32 (48.49%)		9 (60%)			
- Non-MetS	30 (60%)	34 (51.51%)		6 (40%)			

*p value<0.05

Table 3 summarizes the correlation between screen time categories and the prevalence of overweight/obesity, MetS, IR, and MetS components. Males had higher risk for moderate screen time by 2.685-fold than females. It is similar to another study with the lower risk, 1.69-fold (dos Santos Farias *et al*., 2021). Other found higher risk in male by 3.6-fold at the age of 16 years-old (Trang *et al*., 2013).

Subjects with moderate screen time had a higher risk for being overweight by 5.643-fold, and being obese by 3.737-fold than recommended screen time ($p<0.05$). But heavy screen time did not correlate with the incidence of overweight and obesity, as the prevalence of obesity was dominant. A study found that screen time of more than 2 hours/day increases the risk of being overweight by 1.06-fold, and obesity by 1.10-fold (de Souza *et al*., 2020), which was lower than this result. The underlying mechanism of screen time could be contributing to obesity via: the increment of sedentary activity, unhealthy diet stimulated by the advertisement of unhealthy foods, the frequency of snacking while viewing, and sleep duration and quality (Strasburger *et al*., 2011). The moderate screen time increases the risk for abdominal obesity by 0.651-fold ($p>0.05$), which contradicts other findings, in which long screen time (>3 hours/day) had a higher risk for abdominal obesity by 2.5-fold in post-puberty adolescents (de Oliveira *et al*., 2023). However, others found a smaller risk for overweight, 1.51-fold (dos Santos Farias *et al*., 2021).

Moderate screen time increases the risk of IR by 4.116-fold in this study, which is in line with the findings that boys with excessive screen time (>2 hours/day) are more likely to have IR (OR=2.42) and hyperinsulinemia (OR=2.73) (Nightingale *et al*., 2017). However, the odds ratio did not perform well in this study, due to different cut-off values. Others also found that the possibility of IR was increased along with screen time duration; those with screen time > 3 hours/day had the possibility of IR by 16.4% (Nightingale *et al*., 2017). Moderate screen time increased the risk of MetS by 2.185-fold, and 32.421-fold in heavy screen time. This finding was in line with the findings that screen time had a positive association with MetS; each hour screen time addition increased the risk of MetS by 21% (OR = 2.20-fold) (Khan *et al*., 2019). Other also found the increment risk of MetS was a dose-response, in which 2 h/day (OR=1.21, 95% CI=0.54–2.73), 3 h/day (OR=2.16, 95% CI= 0.99–4.74), 4 h/day (OR=1.73, 95% CI=0.72–4.17) and ≥5 h/day (OR=3.07, 95% CI=1.48–6.34) (Mark and Janssen, 2008).

Conclusion

Adolescents with screen time more than 3 hours/day were older, heavier, and experienced shorter sleep duration than adolescents with recommended screen time, and had higher fasting blood glucose, fasting insulin, and

HOMA-IR value. Screen time more than 3 hours/day increases the risk of overweight/obesity, IR, MetS, and causes insufficient sleep duration in adolescents.

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